Marconi

6960A

Service

MP-45618

RF Power Meter
6960

Including Option 3964-650 (GPIB Interface)

AMENDMENT RECORD

The following amendments are incorporated in this manual.

Amendment No.	Date	Issued at serial no.:
Am. 1	Mar. 85	518
Am. 2	July 86	1069
Am. 3	Apr. 87	1570
Am. 4	Nov. 87	1820

© MARCONI INSTRUMENTS LTD. 1984
Printed in the UK

Print code : D-11/87, MI 3c
Part no. 46881-553L

46881-805G FOR 6960A

CONTENTS

PRELIMINARIES

Title page
Contents
Notes and Cautions

CHAPTERS

1 General information
2 Installation
3-1 Operation
3-2 Applications
4 Technical description
5 Maintenance
6 Replaceable parts
7 Servicing diagrams

These chapters are contained in a separate Operating Manual Vol. 1.

HAZARD WARNING SYMBOLS

The following symbols appear on the equipment :

Symbol	*Type of hazard*	*Reference in manual*
⚠	Static sensitive device	Vol. 2, Page (iv)
⚠	Supply voltage	Vol. 2, Page (iii)

Note...

Each page bears the date of the original issue or the code number and date of the latest amendment (Am. 1, Am. 2 etc.). New or amended material of technical importance introduced by the latest amendment is indicated by triangles positioned thus ► .,... ◄ to show the extent of the change. When a chapter is reissued the triangles do not appear. Any changes subsequent to the latest amendment state of the manual are included on inserted sheets coded C1, C2 etc.

NOTES AND CAUTIONS

ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

Removal of covers

⚠ Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, short together the L (live) and N (neutral) pins of the mains plug.

Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

Primary fuses

⚠ Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

CAUTION : STATIC SENSITIVE COMPONENTS

Components identified with the symbol ⚠ on the circuit diagrams and/or parts lists are static sensitive devices. The presence of such devices is also indicated in the equipment by orange discs, flags or labels bearing the same symbol. Certain handling precautions must be observed to prevent these components being permanently damaged by static charges or fast surges.

(1) If a printed board containing static sensitive components (as indicated by a warning disc or flag) is removed, it must be temporarily stored in a conductive plastic bag.

(2) If a static sensitive component is to be removed or replaced the following anti-static equipment must be used.

A work bench with an earthed conductive surface.

Metallic tools earthed either permanently or by repeated discharges.

A low-voltage earthed soldering iron.

An earthed wrist strap and a conductive earthed seat cover for the operator, whose outer clothing must not be of man-made fibre.

(3) As a general precaution, avoid touching the leads of a static sensitive component. When handling a new one, leave it in its conducting mount until it is required for use.

(4) If using a freezer aerosol in fault finding, take care not to spray programmable ICs as this may affect their contents.

WARNING : HANDLING HAZARDS

This equipment is formed from metal pressings and although every endeavour has been made to remove sharp points and edges, care should be taken, particularly when servicing the equipment, to avoid minor cuts.

Lithium: A lithium battery is used in this equipment. Under no circumstances must any lithium battery be crushed, incinerated or disposed of in normal waste. They must be separately and securely packed and any exposed electrical connections adequately insulated to avoid a short circuit occurring during transit. They must be clearly identified to show the nature of the hazard and then disposed of in a safe manner by an authorized toxic waste contractor.

WARNING : TOXIC HAZARD

Many of the electronic components used in this equipment employ resins and other chemicals which give off toxic fumes on incineration. Appropriate precautions should therefore be taken in the disposal of these items.

Chapter 4

TECHNICAL DESCRIPTION

CONTENTS

Para.
1 Overall circuit description
6 Detailed technical description
6 Analogue p.c.b.
47 Power reference
51 Processor p.c.b.
70 Keyboard and display p.c.b.
72 GPIB interface module
80 Software description

Table — Page
1 Attenuator control ... 4
2 Sensor Zener voltages 6
3 PPI port allocations 16

Fig.
1 RF Power Meter 6960 block diagram 2
2 First amplifier 3
3 Spike blanking 4
4 Overall timing 7
5 7543 Serial D-A 8
6 Step-up voltage regulator 9
7 Step-down voltage regulator 10
8 Machine cycle : Wait state and Fetch instruction (AA0Z) 12
9 Memory decoding 14
10 Simplified reset control circuit 15
11 Interface bus structure 18
12 Handshake procedure 20

OVERALL CIRCUIT DESCRIPTION

1. Refer to the 6960 block diagram shown in Fig. 1. The r.f. sensor gives a low d.c. voltage when power is applied. This d.c. signal is converted to an a.c. signal by the signal chopper enabling high gain, low noise amplifiers to be used.

2. The chopped signal is fed to the first amplifier which is split into two parts, the first part being in the r.f. sensor package and the other in the power meter. The signal is then passed to the spike blanking circuit which removes spikes on the edges of the square wave signal produced by the signal chopper. The following buffer also corrects for sensor non-linearities. The signal is then fed to the 1st attenuator which, together witb the 2nd attenuator controls the gain of the amplifier strip in 10 dB steps. The 2nd and 3rd amplifiers provide the rest of the required gain. The 4th amplifier, together with the gain D-A, provides fine adjustment of the a.c. gain.

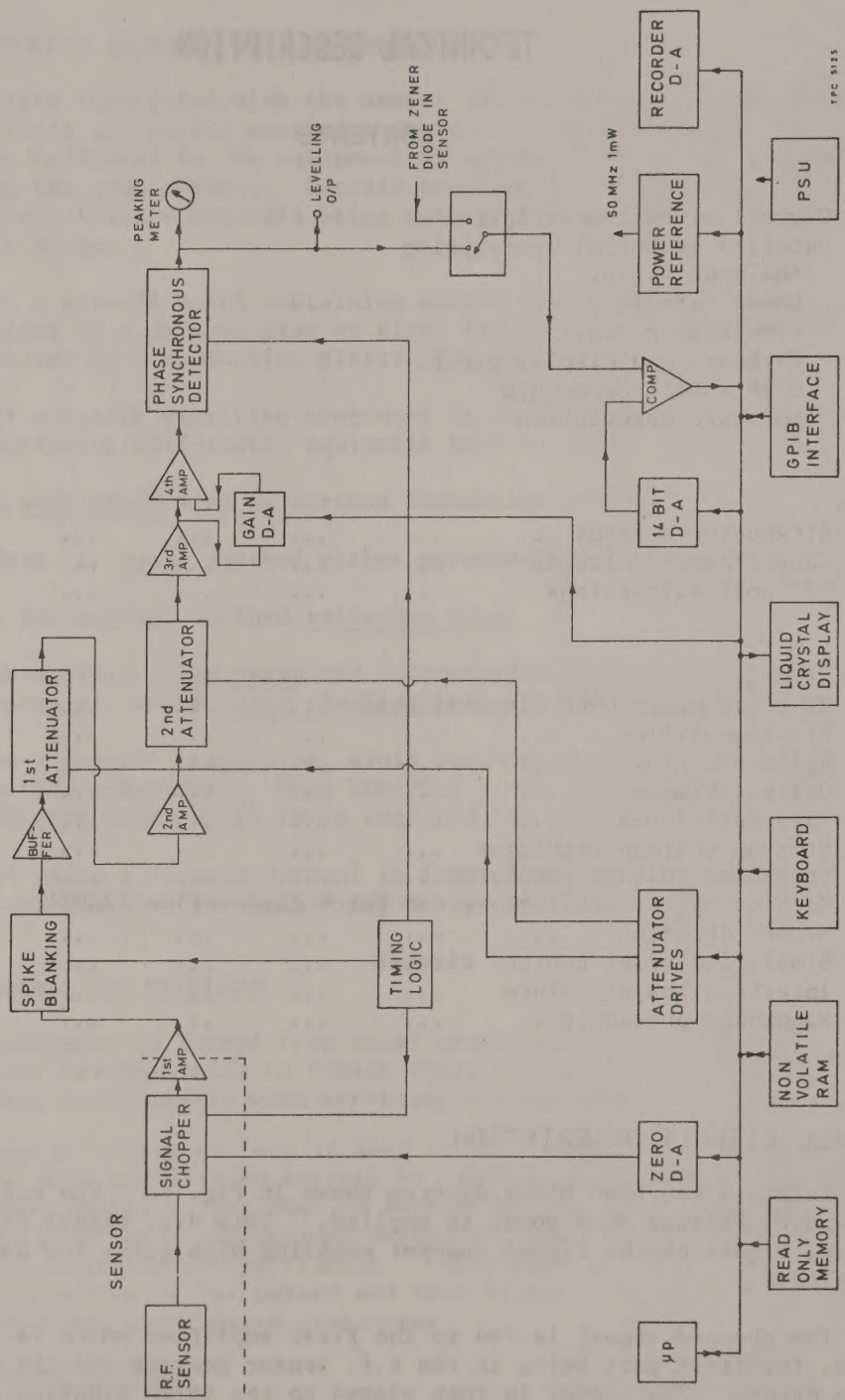


Fig. 1 RF Power Meter 6960 block diagram

3. The phase synchronous detector then synchronously de-modulates the a.c. signal. Timing signals for the signal chopper, spike blanking and the detector are provided by the timing logic. The recovered d.c. signal passes to the peaking meter and, via a switch to the comparator.

4. The microprocessor (μP) runs the program stored in read only memory. Data storage is achieved by using non volatile RAM (Random Access Memory). Outputs from the microprocessor drive the zero D-A, the 14 bit D-A, the gain D-A, the recorder D-A, the attenuator drives, the liquid crystal display, the GPIB interface and the power reference. Inputs to the microprocessor are taken from the comparator, the keyboard and the GPIB interface.

5. Power for all of the stages is provided by the PSU.

DETAILED TECHNICAL DESCRIPTION

Analogue p.c.b.

6. Refer to Chap. 7, AA01 circuit diagram.

7. First amplifier (sheet 1). IC1 and associated components form the second part of the 1st amplifier, the first part being in the power sensor assembly. When using the 6910 series sensors this amplifier has a gain of approximately 1000. Fig. 2 shows a simplified complete amplifier.

8. AC gain is controlled by the components in the emitter circuit of the power sensor transistor. DC bias for the transistor is set by R1 to R5. C2, C6 and C9 control the high frequency response and the capacitor in the sensor controls the low frequency response. The amplifier has a band-pass characteristic centred at the chop rate of 925 Hz.

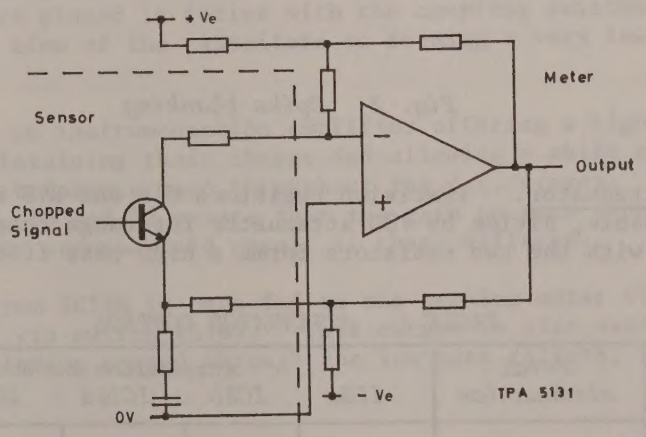


Fig. 2 First amplifier

9. 0 VA control. IC2, R10, R11 and TR1 provide a very low offset source follower which provides an earth reference from the signal ground in the power sensor. This earth reference, indicated by 0 VA, is used by the rest of the a.c. gain stages. D1, D2 and R9 ensure that the earth reference only moves a small amount (about 0.5 V) when no sensor is connected to the power meter.

10. Spike blanking. The spike blanking circuitry, R114, C16 and IC3c, remove spikes that are generated on the leading and trailing edges of the chopped d.c. signal from the r.f. sensor (see Fig. 3). IC3c and C16 act as a sample and hold circuit. The hold period is from when the signal chopper changes state and lasts for a period of 180 µs. R114 reduces errors caused by the hold time interfering with large signal levels at high r.f. power levels. IC4b acts as a high impedance buffer for the signal from the sample and hold.

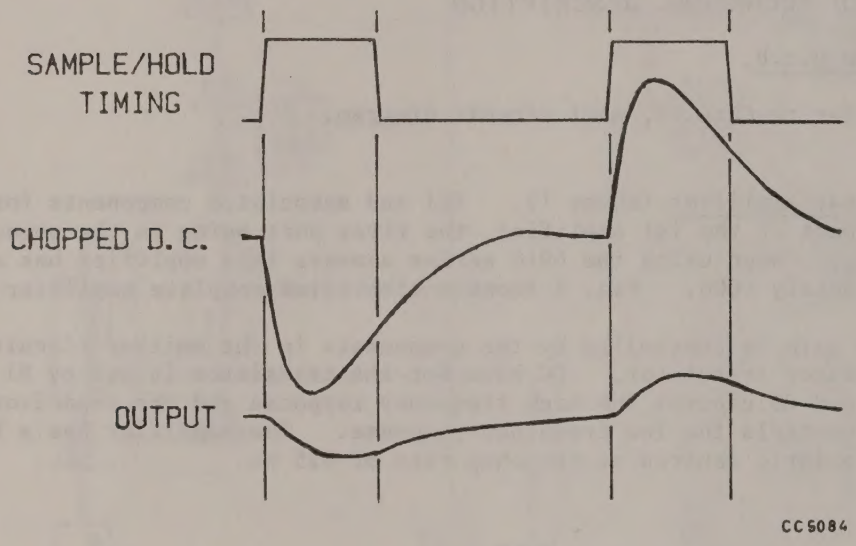


Fig. 3 Spike blanking

11. First attenuator. Precision resistors R14 and R15 with IC3a, IC3b form a switchable, divide by 100 attenuator for range changing (see Table 1). C23 together with the two resistors forms a high-pass filter for bandwidth control.

TABLE 1 ATTENUATOR CONTROL

Range	*Total attenuation*	*Attenuator switches*				
		IC3a	*IC3b*	*IC10a*	*IC10b*	*IC10c*
1	None	ON	OFF	ON	OFF	OFF
2	1/10	ON	OFF	OFF	ON	OFF
3	1/100	OFF	ON	ON	OFF	OFF
4	1/1000	OFF	ON	OFF	ON	OFF
5	1/10000	OFF	ON	OFF	OFF	ON

12. Second amplifier. IC4a with feedback components R22 and R23 form the second amplifier. The gain is approximately 25. C35 controls the high frequency roll off.

13. Second attenuator. R24 to R26 and IC10 form the second attenuator. The principle of operation is the same as the first attenuator described above. This attenuator also has a divide by 10 setting.

14. Third amplifier. The third amplifier stage has a gain of about 35. Resistors R30 and R31 control the gain of IC11a. C38 controls the high frequency roll off.

15. Fourth amplifier. The fourth amplifier is different from the other amplifier stages, in that its gain can be controlled very precisely. It is basically a standard gain stage (IC11b, R37, R38), but having both inverting and non-inverting inputs. The main signal is applied to the non-inverting input which has a gain of approximately 3. When a signal is applied to R37 and the inverting input, from the gain D-A which uses the main signal as its reference, the gain of the amplifier is reduced. This allows the gain to be finally controlled over the range 1 to 3.

16. Phase synchronous detector (sheet 2). The input a.c. signal is restored to d.c. by this circuit. Samples of the signal are taken on each half cycle by closing the switches IC14a and IC14d alternately, with C49 and C50 charging up to the sample voltage during the time the switch is closed. These sample and hold capacitors must be able to charge and discharge rapidly to ensure a fast response to changes in signal level. The time constant is determined by the effective impedance of the switch and the output of 4th amplifier IC11b and the value of C49 and C50. Together these allow an almost complete sample to be obtained within the sample period.

17. When the power meter is on the most sensitive range (range 1), resistors R53 and R54/R115 are placed in series with the coupling switches. These increase the charge time of the capacitors so forming a very low frequency low-pass filter.

18. IC15 acts as an instrumentation amplifier offering a high impedance to C49 and C50 so maintaining their charge and allowing a shift of earth reference to the 0 VC reference used throughout the d.c. stages. Precision resistors R34, 35, 36 and 42 ensure that the gain on each input is the same otherwise linearity errors would result if these differed.

19. The output from IC15b is then fed to the peaking meter via R78 and the comparator, IC17, via switch IC16b. This output is also used for the levelling output after being passed through the low-pass filters, R58 and C60, and buffer IC18b.

20. Comparator and A-D conversion. The comparator output is taken to the Serial Input Data (SID) pin of the processor. The inverting input is driven from the 14-bit D-A. The non-inverting input is driven from either the phase-synchronous detector or the Zener diode in the sensor. This arrangement allows the processor to make successive approximation analogue-to-digital conversions. To do this the processor sets the most significant bit of the 14-bit D-A. It then reads SID to check the output of the comparator. If the output of the comparator is high the data is kept; if not the bit is set to reset. The processor continues by setting each bit in turn, deciding whether to keep or discard each bit until all 14 bits have been checked.

21. Sensor Zener diode drive. The Zener diode in the sensor is used to decide which type of sensor is in use. The Zener diode is driven from a 5 mA constant current circuit consisting of R77, R116, D10, D11 and TR14. The voltage from the Zener diode is scaled by R112 and R113 before being applied to the comparator.

22. The type of sensor in use defines the required scaling and linearity corrections that must be applied to give a true power reading. Table 2 indicates the Zener voltages used with the appropriate scaling and corrections that are applied.

TABLE 2 SENSOR ZENER VOLTAGES

Zener voltage	*Sensor Type No.*	*Sensor top power*	*Thermo-electric sensor linearity correction*	*Diode sensor linearity correction*
2.7	0920	10 µW	NO	YES
3.3	-	10 µW	NO	NO
3.9	Spare	-	-	-
4.7	-	30 mW	NO	NO
5.6	6910	100 mW	YES	NO
6.9	6912	100 mW	YES	NO
9.2	-	10 W	YES	NO
10.0	-	100 W	YES	NO

23. Timing logic (sheet 1). ICs 5 to 9 and their associated components provide all the timing signals for the power meter. Outputs from this section of circuitry drive the signal chopper in the power sensor, the spike blanking and the phase synchronous detector. The basic frequency of operation is 925 Hz.

24. The master oscillator is IC5 which is a gated astable (4047) set permanently on by its control lines. Three outputs are provided by IC5; pin 13 is at twice the 925 Hz chop rate and pins 10 and 11 provide complementary 925 Hz square waves.

25. The output from IC5 pin 13 drives IC6 which is wired as a monostable with a period of 180 µs. The timing components of IC6 are R18, R55 and C24. The output from IC6 provides the sample/hold timing for the spike blanking switch, IC3c.

26. The output from IC5 pin 13 also drives the input of one half of IC7, a precision dual monostable. The first monostable provides the delay before the sample pulse required by the phase synchronous detector. This then drives the second monostable providing sample pulses on each half cycle of the chopped waveform. Two NAND gates, part of IC8, are used to direct the pulses to the correct sample switch in the detector.

27. Both of the 925 Hz signals from IC5 are used to derive the chopper drive signals for the power sensor. Both signals are delayed at the input of IC9, a dual D-type bistable, by the action of R27, C32 and R28, C33. Outputs at pins 1 and 13 are out of phase, with the signal from pin 13 having the greater duration and leading that from pin 1 by a fractional amount. The difference in phase relationship ensures a predetermined signal chopper f.e.t. on/off sequence of operation.

28. Fig. 4 shows the relationships of the timing signals.

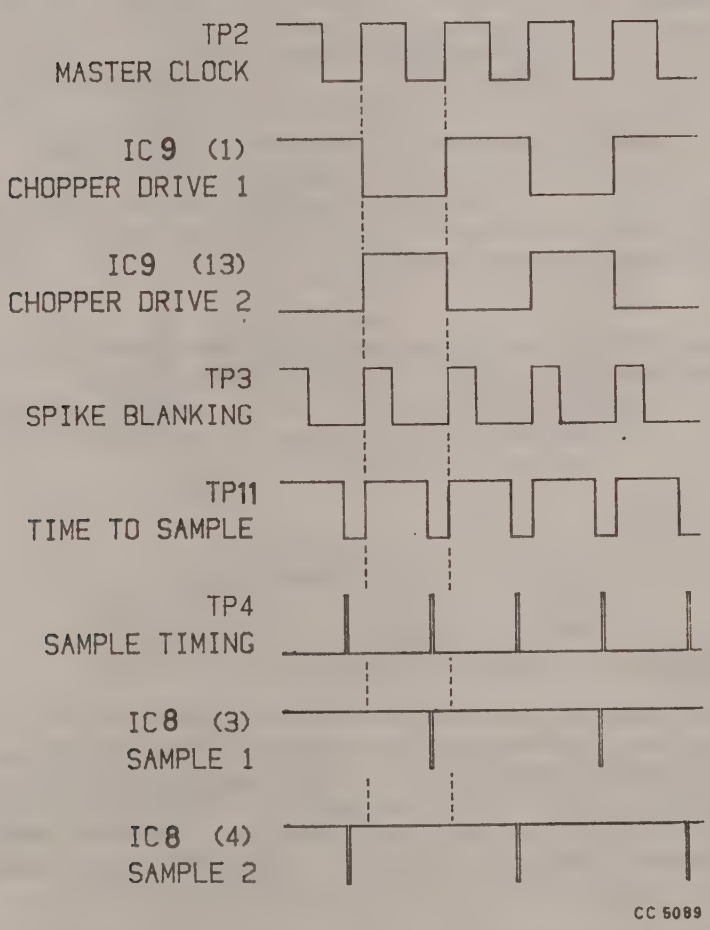


Fig. 4 Overall timing

29. D-A converters. The 14-bit D-A (sheet 2) is a CMOS multiplying D-A converter. Its digital inputs are generated on processor p.c.b. AA02. The D-A IC21, with operational amplifiers IC22 and IC23, is arranged to give a bipolar output of approximately ±6.2 V. Resistors R72 and R76 adjust any offsets generated by the operational amplifiers and R70 adjusts the centre point of the D-A output.

30. The -6.2 V reference required by the D-A circuit is generated from an ultra-stable Zener diode, D13. The Zener diode is driven from a 7.5 mA constant current source consisting of R74, R75, D14 and TR6.

31. Serial D-A's. The Gain D-A (sheet 1) Zero D-A and Recorder D-A (both sheet 2) are all based on the same type of multiplying D-A converter, the AD 7543. This device is special in that data is loaded into it serially (see Fig. 5). The DAC's logic circuitry consists of a 12-bit serial-in parallel-out shift register and a 12-bit DAC input register. Serial data at the SRI pin is clocked into the shift register on the trailing edge of STB3. Once the shift register is full its contents are loaded into the DAC input register by sending LD1 low. These control signals are derived on the processor p.c.b. AA02.

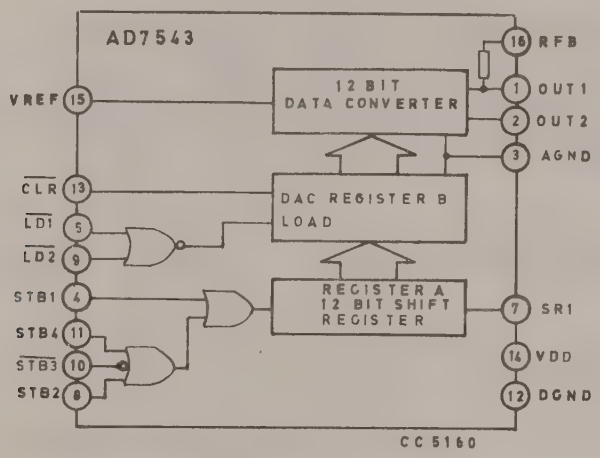


Fig. 5 7543 Serial D-A

32. The Gain D-A is arranged for unipolar output using IC13. See 'Fourth amplifier' above for more details of how this D-A is used.

33. The Zero D-A circuitry provides a small voltage which is sent to the sensor to null out any offsets generated by the signal chopper. The D-A, IC19 and IC20a provides a unipolar 0 to +6.2 V output. This is fed to operational amplifier IC20b which also has a -6.2 V reference input. This provides a -3.1 V to +3.1 V output from IC20b pin 7 which is then scaled down by R67 and R68 before going to the sensor. The -6.2 V reference for IC19 and amplifier IC20b is generated by a low drift Zener diode, D12.

34. The Recorder D-A provides a 0 to +10 V output for use with chart recorders etc. The -10 V reference voltage to do this is generated from the ultra-stable -6.2 V reference D13. It is amplified to -10 V by IC18a and associated components. R81 is used to adjust the -10 V to give the correct scaling to the recorder output. R82 provides the ability to null out any offset on IC25, part of the D-A circuit.

35. Power supply (sheet 3). Four basic d.c. supplies are required by the 6960 Power Meter. Positive and negative 15 V rails are used for all the amplifiers, a 5 V low current rail is used for the timing circuitry and a high current 5 V for the processor and GPIB boards. Basically there are three parts to these supplies; a raw d.c. supply, switching regulators and in all cases, except for the high current 5 V supply, linear regulators.

36. The raw d.c. supply is provided by mains transformer T1, bridge rectifier D15 and reservoir capacitor C82. The primary circuit of T1 is switched to cater for mains supply inputs of 115 V and 230 V. This raw d.c. supply varies from about 10 V to 20 V depending on the actual supply voltage.

37. The +15 V and -15 V supply rails are derived from a step-up switching regulator set for approximately 20 V out, followed by linear regulators to give 15 V. This ensures clean supply rails for the amplifier stages.

38. The theory of the switching step-up regulator is as follows (refer to Fig. 6): when the switch closes, the applied voltage (Va) drops to almost zero (Va-Vs), and the voltage Vin-Vs is applied across the inductor, causing the inductor current to increase linearly. Because the applied voltage is less than the output voltage, the diode is reverse biased and current cannot flow to the output. Again, when the switch opens, the inductor current cannot change instantly, and the applied voltage changes to the total of the output voltage plus the diode voltage. At this time current can flow through the diode to the load capacitor, and the inductor current decreases at a linear rate, determined by Vout-Vd-Vin. Timing adjustments control the average diode current (Id) so it is equal to the load current. If the load current is less than the maximum output current, off time is increased by a dead time with no current to the output. Input current can flow during both on and off times, so the average input current is always greater than the output current.

39. IC26 contains most of the components required by this type of regulator. The switched d.c. is also used to provide a simple negative supply. C85 a.c. couples the switching power to d.c. restoration diode D17. D18 then rectifies it, with C86 providing the output capacitance.

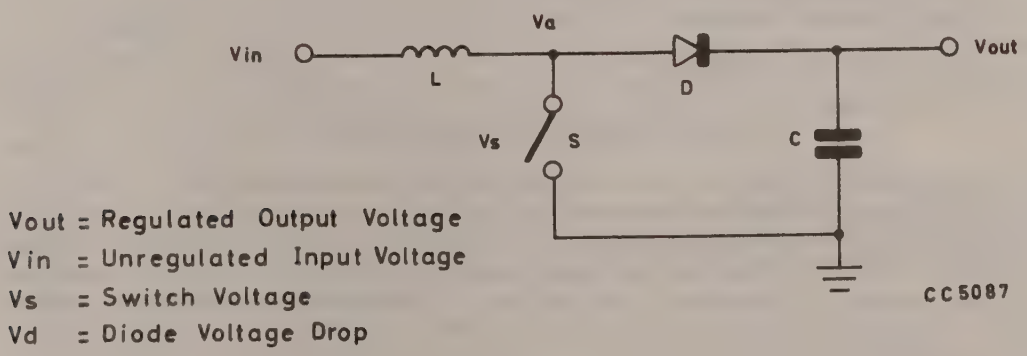


Fig. 6 Step-up voltage regulator

40. The positive and negative outputs from the switching regulator are filtered by L2, L3, C87 and C88 before being applied to the inputs of the linear regulators. IC27 is the +15 V three terminal regulator and IC28 the -15 V regulator. C89 and C90 decouple the outputs of IC27 and IC28 to reduce noise and possible oscillations. D32 to D35 protect the regulators if one or other fails.

41. The low current +5 V is used by the timing logic. This is derived from the +15 V rail by series resistor R89 and Zener diode D19.

42. The high current +5 V is used by the processor board, AA02; the display board AB01 and the GPIB board. The regulator is of the step-down switchmode type.

43. The basic theory of the step-down switchmode regulator (refer to Fig. 7) is as follows : When switch S closes, the voltage Va rises close to Vin (Vin-Vs), and the voltage Va-Vout is applied across the inductor causing the current to rise from zero. This current flows from the switch through the inductor and into the load and output capacitor. When the instantaneous inductor current, iL, is less than the load current, the capacitor provides the extra current and Vout decreases slightly. When iL exceeds the output current the remaining current flows into the capacitor, increasing Vout; iL will increase until the switch is turned off. At this instance, since the inductor current cannot change instantly, Va falls to -Vd so diode D can turn on and provide the inductor current. The voltage across the inductor is now -(Vout-Vd) so the change in inductor current will be negative. The inductor current continues to fall toward zero until S turns on again and the cycle is repeated. The electronics in the system controls the on and off time of S so that the average inductor current equals the output current; the average capacitor current will be zero, and Vout will remain constant.

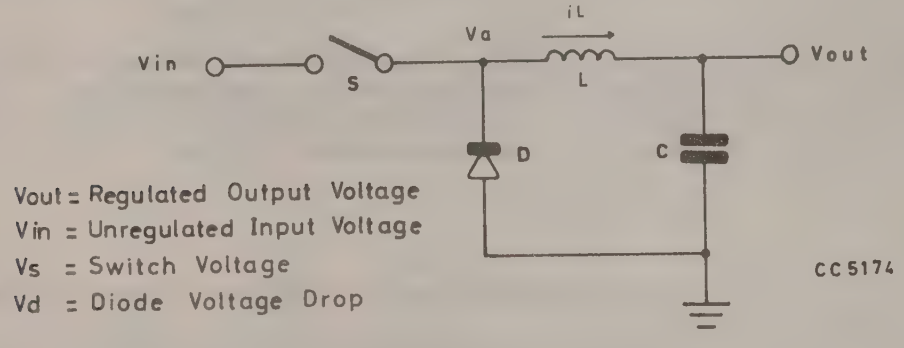


Fig. 7 Step-down voltage regulator

44. The controlling of the +5 V regulator is performed by IC29. Transistors TR7 and TR8 level shift and amplify the output from IC29 to drive the m.o.s. f.e.t. TR10 which acts as the switch. TR9, D22 and C95 ensure that there is sufficient drive voltage available on the gate of TR10 to turn it on properly. L4 is the switched inductor; C98 the output capacitor and D23 the recovery diode. Voltage feedback is via R96 and R97, allowing the output voltage to be set correctly.

45. Additions to the basis supply provide over-current and over-voltage protection. Resistors R105 and R106 sense the current flowing into the inductor. When the voltage across the resistor reaches approximately 0.6 V, TR13 is turned on; which turns on thyristor D27. This removes the gate drive from the m.o.s. f.e.t. switch, TR10. The thyristor is held on by the current flowing through l.e.d. D29, and series resistor R110. When the output voltage

exceeds 5.6 V, Zener diode D30 starts to conduct and will fire thyristor D31 when enough current is flowing through the Zener diode. When D31 is turned on, a very high current is drawn from the supply and the current limit circuit comes into operation.

46. The +5 V supply is filtered by the action of L5 and C99.

Power reference

47. Refer to Chap. 7, AC04 circuit diagram.

48. The power reference supplies a low spurii 50 MHz carrier levelled at 1.00 mW. The reference oscillator is enabled by a digital control signal applied to the transistor switches TR1 and TR2. Applying 0 V turns TR1 off thus turning TR2 on, enabling the power reference. When a positive voltage of greater than 1.5 V is applied to R1, TR1 turns on, turning TR2 and the power reference off.

49. TR3 and associated components form a modified Hartley oscillator that can be level controlled by the second gate on the m.o.s. f.e.t. Output is coupled from the source of TR3 by C8 to the matching and harmonic rejection circuit consisting of C10 to C12 and L3. The matching circuit then feeds detector D2 and d.c. blocking capacitor C18. As the source impedance of a levelled circuit is 0 Ω a 50 Ω source resistor is required. This is combined with a 2 dB attenuator in R11. R12 and R13 form the rest of the attenuator which then passes r.f. power to the output.

50. The output from the detector diode, D2 feeds one side of the levelling comparator IC1a. The -6.2 V voltage reference input is buffered by IC1b, the gain being set by R15, R16, R18 and R19. The resultant reference voltage is fed via D3 which is used to provide temperature compensation for D2, to the non-inverting input of IC1a. The output of IC1a drives the level control gate of the oscillator transistor TR3.

Processor p.c.b.

51. Refer to Chap. 7, AA02 circuit diagram.

52. The processor board contains an 8085AH-2 CPU, buffers for the address and data lines, address decoding, EPROM, non-volatile RAM, programmable peripheral interfaces (PPIs) and reset circuitry. Components and their interconnections are briefly described below, full descriptions of the 8085 CPU and 8255 PPIs can be found in "MCS85 Users Manual" publishec by Intel Corporation. The purpose of the c.p.u. is to control the instrument by means of the address and data buses. The program is contained in the EPROM and data is stored in the non-volatile RAM. The c.p.u. is an 8-bit n.m.o.s. microprocessor with interrupts, and features a multiplexed address/data bus.

53. The c.p.u., IC3, uses a 10 MHz crystal for its clock generator. This is internally divided down to give a 5 MHz operating frequency. At power-on a reset is applied to IC3 pin 36. The reset instruction RESET IN, lasting for at least three full clock cycles synchronizes with the internal clock and resets the following:-

(1) Program counter is cleared.

(2) Instruction register is cleared.

(3) Interrupts are disabled.

(4) All tri-state bus lines are floated (ALE is not tri-state).

54. Address decoding. Address and data lines are multiplexed, pins A8-A15 are output-only lines carrying the high-order byte of memory addresses. AD0-AD7 are bi-directional lines which output the low-order byte of memory addresses and also double as a bi-directional data bus. The top four address lines, A12-A15 are decoded by IC7 3 to 8 decoder to give addressing blocks of 4 k in the bottom half of the memory map.

55. Wait states. The operation of the c.p.u. is directed into read and write sequences called machine cycles. These may contain from 3 to 6 clock cycles (or T states) with the instruction fetch MC1 containing a minimum of four T states and the remainder three (see Fig. 8). A memory read must occur within three clock periods for in this time IC3 places the input into the instruction register.

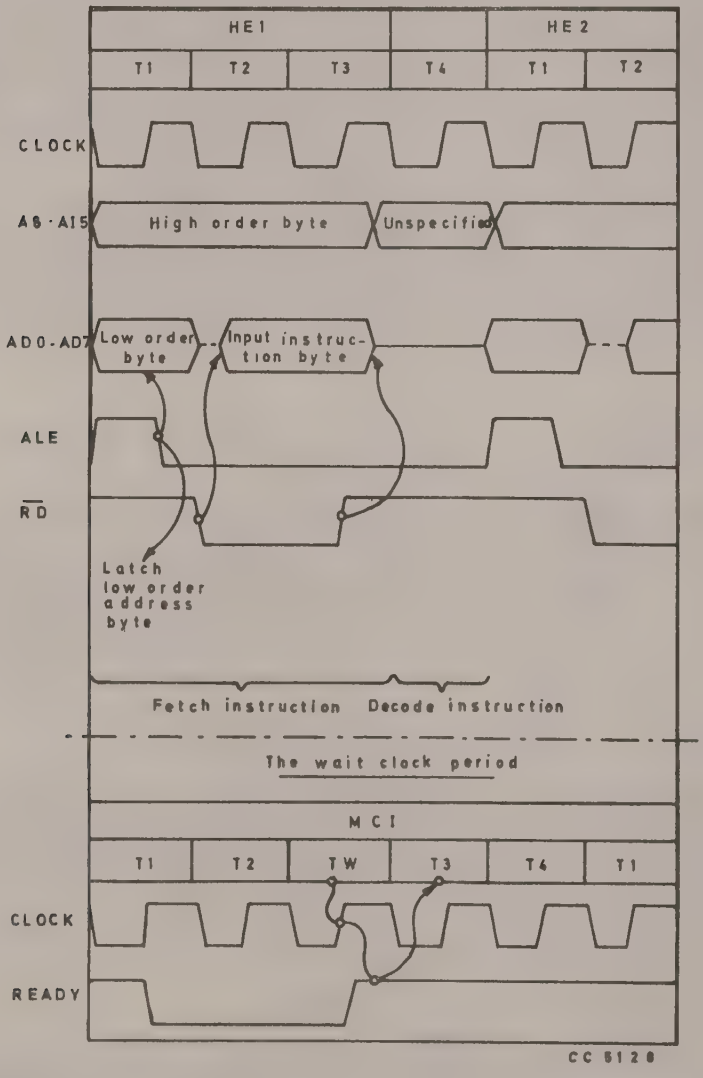


Fig. 8 Machine cycle. Wait state and Fetch instruction (AA02)

56. Slower input/output devices require more time to respond therefore it is necessary to delay the input to the instruction register. Provision for this is made by the ability of the c.p.u. to generate a 'Wait clock periods'. The READY signal line is sampled by the c.p.u. at the clock period T2, if this is at logical low a Wait clock period will follow, further Wait clock periods would be generated until the READY signal line is asserted high One Wait clock period only is required by the 6960, the clock periods and signals generated in the first machine cycle are shown in Fig. 9. IC6 and IC10c,d circuit holds the READY line low for one count only then asserts high, the next clock period T3 then follows.

57. As only Wait states are required by PPIs IC12 and IC13, the Wait clock period is generated only when address line A14 goes high, i.e. for addresses in the range 4000H to 7FFFH.

58. Address and data buffering. IC4 Address buffer is an octal transparent latch and de-multiplexes the low-order address and data lines by means of the ALE (Address Latch Enable) signal. Timing requirements cause some noise spikes on the output latched address lines; these are caused during the transition from Data to Address and are to be expected.

59. IC5 Data buffer is an octal bus transceiver and buffers data to and from the data bus (D0-D7). The direction of the transceiver is controlled by the read (RD) signal from the c.p.u. Data is sent to the c.p.u. when the read line is logical low .

60. EPROM. The instrument operating program is contained in IC8, which is an ultraviolet erasable EPROM. The EPROM is an 8 k x 8-bit device.

61. The EPROM is accessed when its CE enable line is logical low . The outputs remain tri-state until the output enable, OE, line goes low. At this time the data from the location in the EPROM specified by the state of address lines A0 to A12 is placed on the data bus. Fig. 9 shows the decoding for the EPROM and other devices.

62. RAM. The random access memory is a 2 k x 8-bit c.m.o.s. device. This allows a small battery to provide standby power making the RAM non-volatile. The select line from decoder IC7 is inverted by IC10b before being NANDed with the c.p.u. Reset line. The NAND gate is made up from D6 to D9, R17, R18 and TR2. The output from TR2 collector drives IC9 CS. When the 6960 is powered down TR2 is turned off by the reset circuitry ensuring that no locations of the RAM can be written to as the +5 V supply fails.

63. The direction of data to and from IC9 is controlled by the output enable, OE, and write enable, WE, control lines. When WE is logical high and OE is low, data is output from the RAM to the data bus. If OE is high and WE is low data is written into the RAM.

64. When the 6960 is powered down, the standby power for IC9 comes from Lithium battery B1. The battery is isolated from the +5 V power supply by special diodes D10 and D11. D10 has extremely low reverse leakage so that no power passes from the battery to the supply rail. D11 has a very low forward voltage so that the battery can be used until the voltage out is approximately 2 V. The expected lifetime of the battery is a minimum of 5 years and possibly 10 years.

ADDRESS HEXADECIMAL		ADDRESS LINES				SELECTED IC
		A15	A14	A13	A12	
8000H	-	0	1	1	1	SPACE
7000H	PPI 2 (3 LOCATIONS)	0	1	1	0	IC12
6000H	PPI 1 (3 LOCATIONS)	0	1	0	1	IC13
5000H	GPIB SWITCH (1 LOCATION)	0	1	0	0	AA11 IC7
4000H	GPIB CONTROLLER (8 LOCATIONS)	0	0	1	1	AA11 IC1
3000H 27FFH	↑ DATA AREA ↓(RAM)	0	0	1	0	IC9
2000H	↑ OPERATING	0	0	0	1	IC8
1000H	PROGRAM ↓	0	0	0	0	IC8
0000H						

Fig. 9 Memory decoding

65. Reset control. The reset control circuitry is used to inform the c.p.u. of a power-down situation and to ensure that the c.p.u. itself powers down clearly. Fig. 10 shows a simplified diagram of the reset control circuit. The TRAP, non-maskable, interrupt is used to inform the c.p.u. of an impending loss of supply. When this interrupt occurs, the c.p.u. stores the current front panel settings in STORE 0 so that they may be recalled on power-up. When the RESET IN line on the c.p.u. becomes logical low the c.p.u. halts any processing and sends all outputs to a tri-state mode.

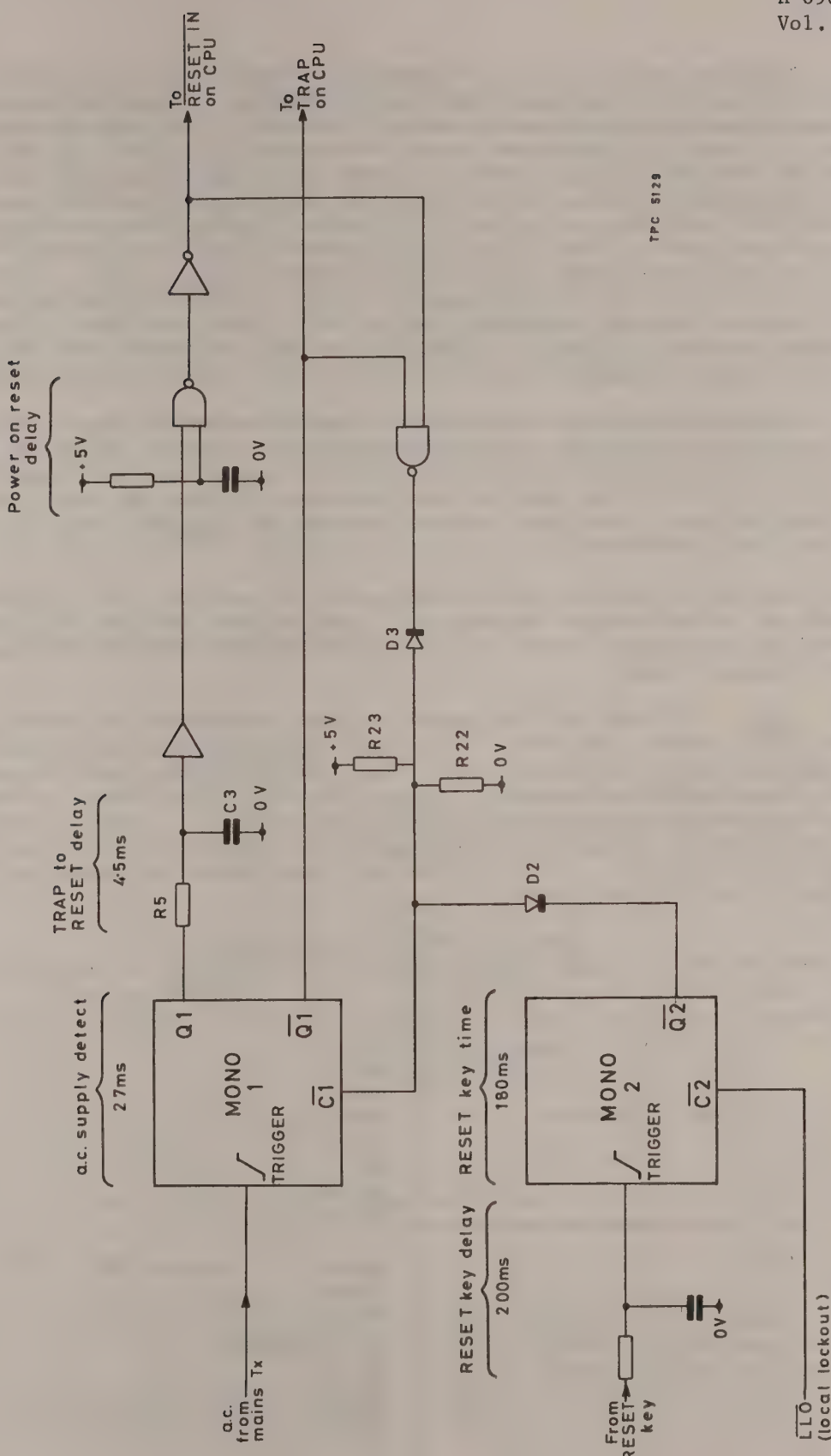


Fig. 10 Simplified reset control circuit

66. The first half of dual rectriggerable monostable IC1, is triggered by a.c. derived from the secondary of the mains transformer. Thus the monostable remains triggered until the mains supply is removed. The pulse duration of IC1 part 1 is set to 27 ms so that supply frequencies as low as 45 Hz may be used. When the monostable is no longer triggered the Q1 low output goes high, raising the TRAP interrupt. At the same time Q1 high goes low which sends the RESET IN line of the c.p.u. low 4.5 ms later. During this time the settings are stored in RAM. The 4.5 ms delay is generated by delay network R5 and C3. Q1 low is NANDed together with the c.p.u. RESET IN line by IC2a. The output from the NAND gate is fed via D3 to the clear, C1, input of the monostable. This ensures that the monostable remains in the same state even if the mains supply recovers. Potential divider R22 and R23 also ensure that the monostable stays un-triggered until the +5 V rail has reached a satisfactory value.

67. The front panel key RESET fires the second monostable after a 200 ms delay fixed by R7 and C5. This monostable has a duration of 180 ms. The Q2 low output is taken to the clear input (C1 low) of the first monostable. Therefore the RESET key has the same function as turning the supply off, but allows the c.p.u. to be reset without removing any supplies, ensuring stability of the 6960 amplifiers etc.

68. The dual monostable and the NAND gates, IC1 and IC2, are supplied with power via D4 and storage capacitor C4. This ensures that the CPU, TRAP and RESET IN lines remain steady until all power has been removed from the rest of the processor board.

69. PPIs. IC12 and IC13 are general purpose Programmable Peripheral Interface (PPI) devices type 8255. Each has 24 I/O pins which may be individually programmed in two or three groups. These are three major modes of operation but only one of these is used. For more details of the 8255 it is best to refer to the Intel publication 'MCS-85 User's Manual'. In the operating mode selected the I/O pins are split into groups of 8 which may be used as either input or output pins. Table 3 shows how the groups are allocated and the circuitry to which each goes.

TABLE 3 PPI PORT ALLOCATIONS

PPI	*Port*	*In or Out*	*Bit*	*Controls or Reads*
IC13	A	Input	0	Key 4
			1	Key 5
			2	Key 6
			3	Key 7
			4	Key 8
			5	Key 9
			6	Key DP
			7	Key ENT
	B	Input	0	Spare Keyboard AB01
			1	Spare
			2	Spare
			3	Key - (Minus)
			4	Key 0
			5	Key 1
			6	Key 2
			7	Key 3

TABLE 3 PPI PART ALLOCATIONS (continued)

PPI	*Port*	*In or Out*	*Bit*	*Controls or Reads*
	C	Output	0	Serial D-A and DISPLAY STROBE LINES
			1	CAL D-A LOAD
			2	ZERO D-A LOAD
			3	RECORDER D-A LOAD
			4	DISPLAY DRIVER LOAD
			5	POWER REFERENCE ON/OFF
			6	REAR PANEL BLANKING OUTPUT
			7	LOCAL LOCKOUT TO RESET CONTROL
2 IC12	A	Output	0	14-BIT D-A LEAST SIGNIFICANT BIT
			1	
			2	
			3	
			4	
			5	
			6	
			7	
	B	Output	0	
			1	
			2	
			3	
			4	
			5	14-BIT D-A MOST SIGNIFICANT BIT
			6	SOURCE 1) CONTROL WHICH OF SIGNAL OR
			7	SOURCE 2) HEAD ZENER TO BE MEASURED
	C	Output	0	GAIN CONTROL A
			1	GAIN CONTROL B
			2	GAIN CONTROL C
			3	GAIN CONTROL D
			4	GAIN CONTROL E
			5	SPACE
			6	FILTER CONTROL 1
			7	FILTER CONTROL 2

Keyboard and display p.c.b.

70. Refer to Chap. 7, AB01 circuit diagram. Components on this p.c.b. can be split into two distinct parts. These being the key switches and the display drivers.

71. The liquid crystal display (l.c.d.) drivers IC1 and IC2, are serial input devices thus they only have 3 control lines but provide up to 32 segment drives from each i.c. The serial data is clocked in by a falling edge on the CLX input line. This data is then loaded to the display drive by a logical high on the LOAD signal line. The two integrated circuits are cascaded so that 3 lines control both IC1 and IC2.

GPIB interface module

Circuit diagram : Chap. 7, GPIB p.c.b. circuit diagram

72. This module is an optional item and only fitted to 6960 when remote facilities are required. The module when connected to the rear panel, allows direct connection from a GPIB talker/listener device and implements the full IEEE 488 specifications (no control function).

73. IC1 (8291 GPIB talker/listener integrated circuit) is connected to the microprocessor system providing both talker and listener capabilities. IC2-IC5 transceivers are used to translate the negative true logic and act as drivers. IC6d/IC6c provides the logic low level for the receive instruction T/R1 to IC4, pins 7,9; or the talker high level for IC2,IC3,IC4 and also provides the additional buffering necessary for the three ICs in line. Also fitted on the interface module are the GPIB bus terminator loads R1-R6, the address switch SW1, and its buffer IC7.

74. The function of the board is to provide buffering between the general purpose interface bus and the 8291 GPIB handler. The external controller directs the flow of data on the bus and designates when the 6960 is to send data and when it must receive it. The bus uses 16 signal lines to connect all units of a system in parallel. These lines are sub-divided into data, transfer and interface management buses as shown in Fig. 11.

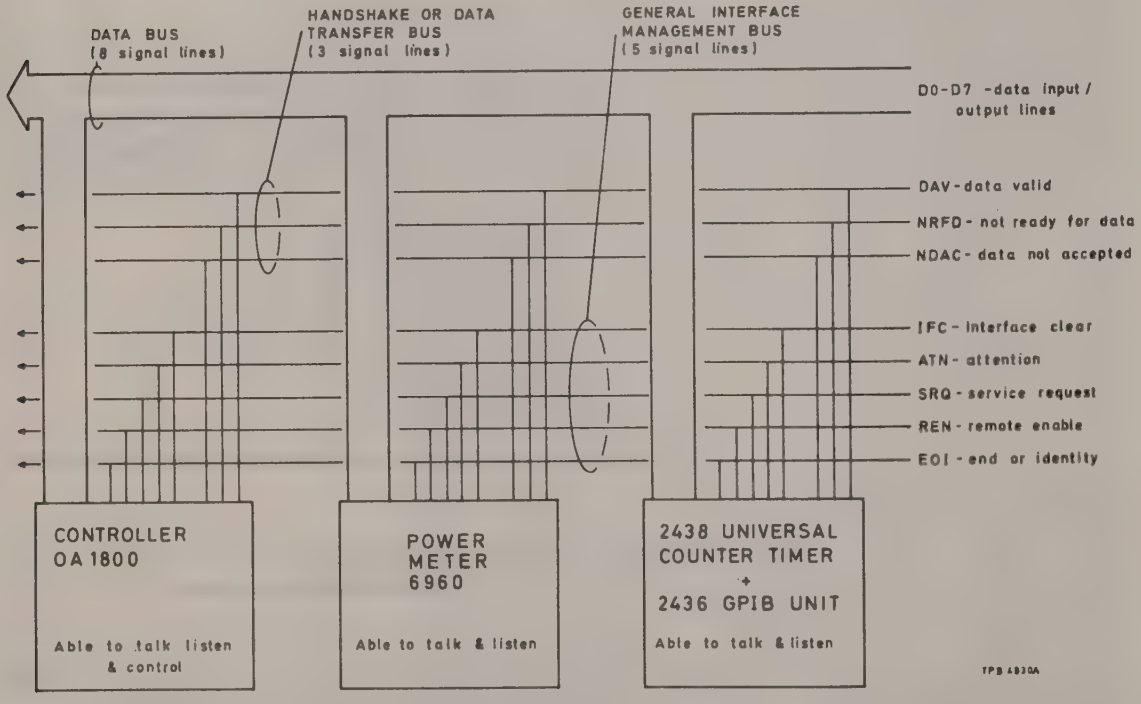


Fig. 11 Interface bus structure

75. Data bus, comprises 8 data input/output lines D0-D7 and is used to transfer the data (commands, addresses and instructions) in bit parallel, byte serial form.

76. Interface management bus, manages the orderly flow of data across the interface and consists of 5 wires carrying the following signals :

Interface clear (IFC); sent by the system controller to clear all device interfaces so that they set to an initial condition.

Remote enable (REN); sent by the controller to enable instruments to be placed under remote control.

Attention (ATN); sent by the controller to indicate that an address or command is on the data lines.

End or identify (EOI); an instrument or controller signal sent to indicate the end of a message.

Service request (SRQ); sent to a controller by an instrument to indicate that it needs service. This can be programmed using the 'SR' program code, details of which are given in the Operating Manual, Vol. 1, Chap. 3, SRQ (Service Request) Function.

77. Handshake or data transfer bus, co-ordinates the flow of data and comprises 3 lines which are used for the handshaking process, by which a talker or controller synchronizes its readiness to send data with a listener's readiness to receive data. The handshake signals are :

Not ready for data (NRFD); asserted (low) by a listener when it is active and not yet ready to receive data. Set high to signal its readiness to receive data, DAV can then be signalled if further data is to be processed.

Data valid (DAV); asserted by a talker to indicate that the data it has placed on the data bus has settled and may be accepted.

Not data accepted (NDAC); asserted by a listener when receiving information from the data lines. Release of the NDAC line tells the data source that new data can be submitted.

78. Bus operation

(i) A sequence of messages may be commenced by the controller asserting IFC on the management bus to set the interface to its initial condition.

(ii) The controller then sets up which instruments are to be listeners by asserting ATN and handshaking the personalized listen address of these instruments over the bus. Similarly the controller designates the talker (only one instrument may talk at a time) by sending its talk address, again with an ATN asserted.

(iii) On removing ATN the talker is then able to place data on the data lines D0 to D7, the transfer of this is controlled by the handshake process and is received by all addressed listeners. The talker typically concludes the sequence by asserting EOI and the controller then resumes control.

(iv) Both the talker and the listeners may be switched by the controller into an inactive state by asserting IFC or sending OTA (other talk address) and UNL (unlisten) on the data bus.

79. Handshake procedure, the handshake is used whenever data is transferred on the bus. When a signal is asserted the function indicated by the line is carried out, e.g. NRFD is asserted to signify the listener's unreadiness to receive data, and unasserted or removed when ready to receive data. A typical handshake is as follows:

(i) Talker (controller) places a byte on the data bus with DAV initially unasserted to show data is not yet valid.

(ii) When all listeners are ready to receive data NRFD is removed with NDAC at this time asserted.

(iii) After a delay to allow the data bus to settle, talker asserts DAV to show data is valid and may be accepted.

(iv) Data byte is transferred, then listeners assert NRFD. When all the listeners have accepted the byte NDAC is removed to signify receipt.

(v) Talker removes DAV, listeners assert NDAC, and the bus reverts to its initial condition ready for the next data byte, a typical cycle is shown below in Fig. 12.

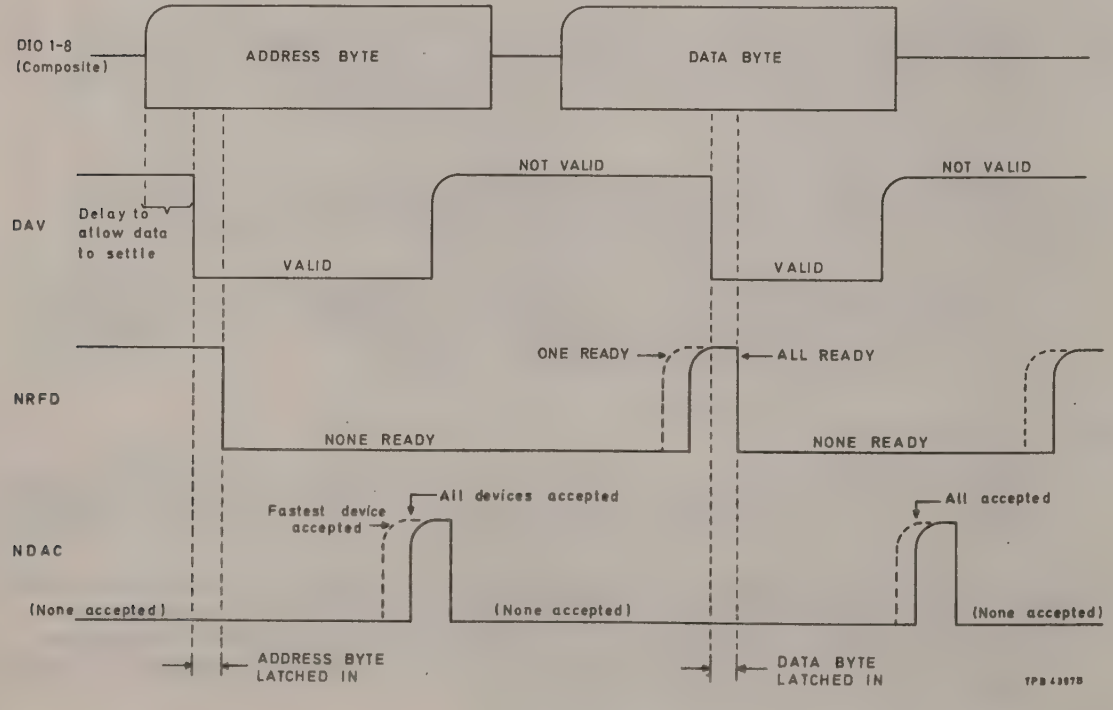


Fig. 12 Handshake procedure

Software description

80. On power-up the processor sets up a stack pointer at the highest working location in RAM, initializes the 8255 PPIs; the display is then set to read '6960' whilst a simple test is made on all RAM locations. The TRAP interrupt is enabled at this point. A checksum byte stored on power-down is checked to ensure data retention. The D-As are then set as the data requires. The program issue is then displayed in the form '1 5 n' for 1/2 second. At this point, if any key is pressed the program jumps to the calaid routines. The 8291A GPIB chip is initialized and the GPIB address is displayed if the chip is present.

81. The main program loop operates as follows:- If it is the first measurement; the range switches are set; the range offset is looked up; the range limits are looked up; the settling time is calculated from the average number; the averaging sample number is set to zero; a single A-D conversion is carried out and stored as the previous average; the measurement counter is reset; if settling time is enabled the status byte in the GPIB output string is set to an 'S'; and the number of conversions required on the inside averaging loop is looked up if in the fast operating mode (GPIB only) else the default value of 400 is used.

82. The inside averaging loop checks to see if any key has been pressed. If so, the program jumps to the keyboard routines. An A-D conversion then takes place and is averaged with the previously stored data. The loop is repeated until the required number of conversions has taken place.

83. The head Zener is then measured by performing an A-D conversion with the switches set to read the diode. The data from the conversion is then used to work out which Zener diode is in use. Data regarding linearity correction and sensitivity are saved.

84. The measured power data is then compared with the range limits stored previously. The program jumps to the range error routine if the limits are exceeded and an SRQ is raised if necessary.

85. The data is then converted into the binary floating point format required by the MATHS package. The range offset is added at the same time.

86. If the filter is in (Range 1) the data is corrected for the gain error of the filter.

87. The out side average (the one selectable from the front panel) is then performed.

88. A check on the sign of the data is carried out and if -ve and the dB mode is selected, UNDERRANGE is flagged and the program jumps to the range error routine.

89. The data is then range corrected so that the top reading on the centre range is 1.000.

90. Diode or thermocouple linearity correction is then applied as required.

91. CAL FACTOR correction is then applied.

92. The RECORDER OUTPUT D-A is then set as required to the following rules:- If in linear mode (W), output is 0 V to +5 V for each range. If in dB mode, output is +5 V for the top of range 3 with a gain of 1.0 V/10 dB.

93. Duty cycle correction is then applied.

94. The resultant data is then turned to mW dependent on the sensitivity of the sensor as indicated by the HEDTYP.

95. The data is then turned to dBm and any dBrel offset added as required.

96. The attenuation offset is then applied if required.

97. The final routine in the MAIN loop basically drives the display and GPIB output. It can be split into various parts :

(1) Round the data according to the amount of averaging that is being applied. This is range dependent in the dB mode.

(2) The settling time is checked if enabled. If the settling time has been reached a flag is set to indicate this.

(3) The measurement result is loaded into the GPIB output buffer and also displayed.

98. If in the GPIB talk only mode the GPIB output buffer is output to the GPIB.

99. An SRQ is raised if SRQ on end of measurement was required.

100. If not in the HOLD mode (GPIB only), the program jumps back to the start of the main loop.

101. If in the HOLD mode, a check is made to see if local lockout is set; if not the program runs round a loop checking for the LOCAL key else it halts the processor.

Chapter 5

MAINTENANCE

CONTENTS

Para.
1 Introduction
5 Static sensitive devices
6 Fault location
7 DC voltages
8 Board layout and preset components
9 Access and layout
11 Dismantling front panel assembly
14 Access to power reference p.c.b.
16 Performance and internal signal tests
16 Switch-on checks
17 Performance specifications
21 Performance tests
27 Internal signal tests (TEST mode)
29 Adjustment and calibration
30 Voltage checks and adjustments
32 Timing adjustments
36 Filter balance adjustment
39 14-bit D-A adjustment
44 Recorder D-A adjustment
47 Power reference adjustment
53 Fault location
57 Power supply faults
59 Signal channel faults
61 Processor board faults

Table Page
1 Performance specifications 5
2 Test mode functions 10
3 Test equipment for adjustment and calibration 12

Fig.
1 Layout, with AA02/1 disconnected 3
2 Arrangement for zero set/carryover test 7
3 Arrangement for instrumentation accuracy test 8
4 Locations of test points and preset potentiometers on AA01 ... 11
5 Filter adjustment 14
6 AA05, Power reference calibration components 15
7 Signal channel waveforms 18

INTRODUCTION

1. This chapter contains information for keeping the equipment in good working order, checking overall performance, fault finding and re-alignment procedures. Before attempting any maintenance on the equipment you are advised to read the preceding chapter containing the technical description.

2. In the case of difficulties which cannot be resolved with the aid of this book, please contact your nearest Marconi Instruments representative. Always quote the type and serial number found on the data plate at the rear of the instrument.

3. When making tests to verify the instrument meets the stated performance limits, allowances must be made for the uncertainty of the test equipment used.

4. Integrated circuits and semiconductor devices are used throughout this instrument and, although these have inherent long term reliability and mechanical ruggedness, they are susceptible to damage by overloading, reverse polarity and excessive heat or radiation and the use of insulation testers.

Static sensitive devices

5. The CMOS integrated circuits used in this instrument have extremely high input resistance and can be damaged by accumulation of static charges (see preliminary pages, Notes and Cautions). Boards that have such integrated circuits all carry warning notices against damage by static discharge.

Fault location

6. Some aid to fault finding is provided by the typical d.c. voltage and signal levels. Tables given are not extensive but are intended as a pointer to further investigation. It is emphasized that each fault table should be studied having regard for the others, since incorrect operation of a circuit may be caused by malfunction of an associated circuit.

DC voltages

7. Voltages given approximate those which can be expected using a 20 kΩ/V meter on a typical 6960 connected to an a.c. supply of 220 to 240 V, 50 Hz.

Board layout and preset components

8. Printed circuit board layouts can be seen in Chap. 7, Servicing Diagrams. Preset and select-in-calibration (SIC) components are also identified there. A further plan view of the presets and their function can be seen in this chapter.

ACCESS AND LAYOUT

Layout, top view (see Fig. 1)

9. To remove top and bottom outer covers simply unscrew the two retaining screws in the rear panel feet; remove the feet and the diecast surround, then slide each cover to the rear and lift off.

10. To remove the processor p.c.b., AA02/1, first unscrew the six self-tapping screws holding the p.c.b. to the side frames. Carefully disconnect the three multiway connectors from the p.c.b. Do not place the p.c.b. assembly on a metallic surface or the battery may be damaged.

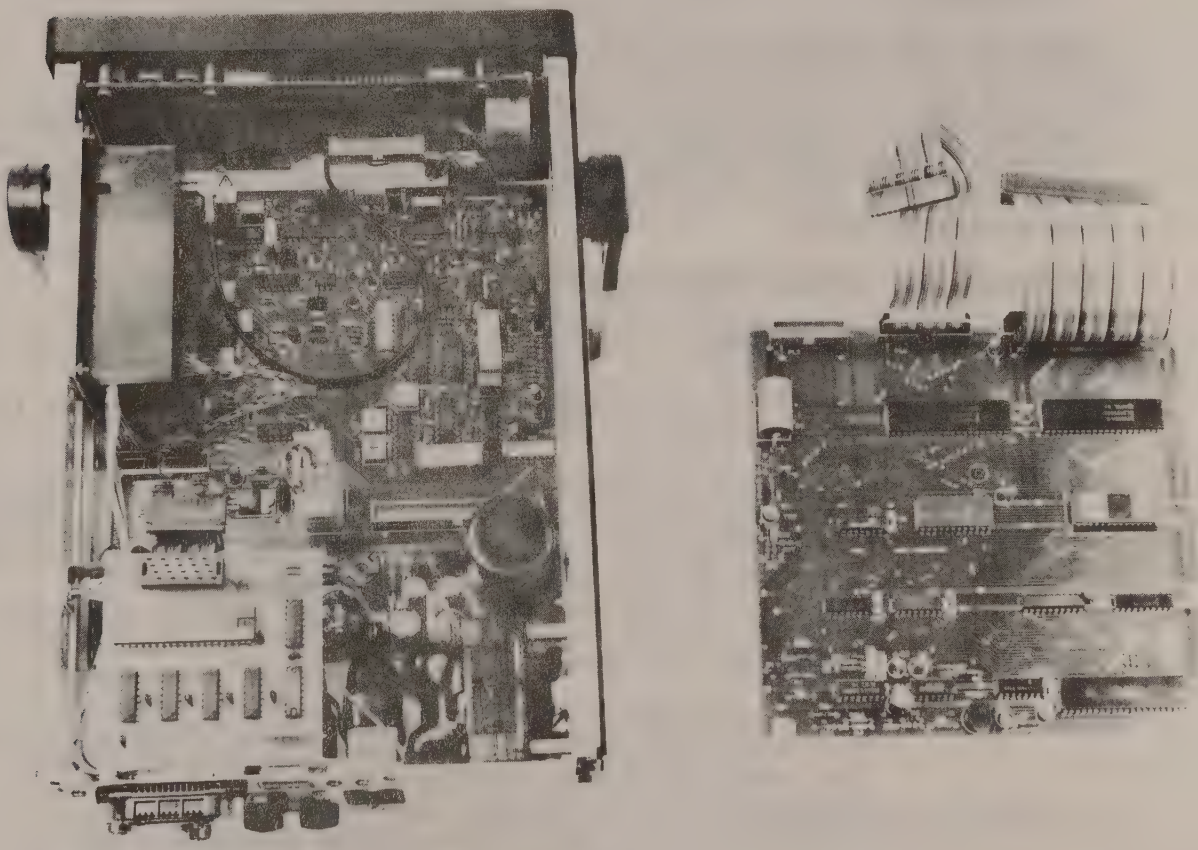


Fig. 1 : Layout, with AA02/1 disconnected

Dismantling front panel assembly

11. Disconnect all sockets that connect the front panel assembly to the rest of the instrument. Remove the four screws holding the side panels to the front panel assembly. The front panel assembly can now be pulled forward and partially removed. The supply switch and its cover must either be disconnected or removed before the front panel can be completely removed. When replacing the front panel assembly as a unit, disconnect the wires from the supply switch at the rear panel fuses and voltage change-over switch.

12. The p.c.b. can now be removed by removing the six screws holding it to the front panel metal work.

13. On re-assembly ensure that all of the push-buttons operate freely and that the display is centred in its surround.

Dismantling rear panel assembly

14. Disconnect the two cables that join the rear panel assembly to the analogue p.c.b. Unsolder the wires from the supply switch at the fuses and voltage change-over switch. Remove the two screws at the ends of the GPIB assembly support plate and lift out the GPIB assembly. The rear panel assembly can now be pulled away after removing 6 screws (4 in one side and 2 in the other).

Access to power reference p.c.b.

15. The power reference assembly must first be removed from the instrument. Remove the two screws holding the mounting plate to the side panel. The four self tapping screws holding the screening can now be removed. When the plate has been removed and the connector pulled off, the p.c.b. may be withdrawn from the box.

PERFORMANCE AND INTERNAL SIGNAL TESTS

Switch-on calibration checks

16. Performing the calibration procedure at switch-on demonstrates that the instrument's measuring circuits are functioning.

Switch-on: At switch-on the 6960's LCD should first display "6960" followed by the software issue number e.g. "IS 7" and then the GPIB address (if GPIB is fitted). If no sensor is connected the LCD will then display the error code "Er 2". Otherwise the instrument should , with no r.f. power applied to the sensor, display either a very low power reading or five dashes and the "under range" annunciator.

Autozeroing: Press [AUTO ZERO]. This should cause the LCD to display the five dashes and the "zero" annunciator. As each of the 6960's five ranges is zeroed, one of the dashes is blanked. When all dashes have been blanked, all ranges are zeroed. After zeroing, the instrument returns to the range previously set, or (if no range was set), to auto- range. With no r.f. power applied, a low power reading or the five dashes and "under range" annunciator, are again displayed.

Autocalibration: Press [LINEARITY FACTOR] and from the bar chart on the sensor labelled LIN F, enter the linearity factor. Press [CAL FACTOR] and enter the 50 MHz reference calibration factor given on the sensor.(For 6910 and 6913 sensors the default figure of 100 applies and no entry is required).

Connecting a 6910 series sensor to the power reference and pressing [AUTO CAL] causes the sensor to be calibrated to the 0 dBm, 50 MHz power reference signal. When autocalibration is completed the reference is switched off (if not previously selected), but if switched on again by pressing [POWER REF] the display should read 0 dBm or 1.00 mW if autocalibration has been successful.

6920 series sensors are calibrated to -30 dBm, and the 0 dBm reference signal should be applied to these sensors via the supplied calibrated 30 dB attenuator.

Performance specifications

17. The performance specifications listed in Table 1 below are reproduced from the SPECIFICATION section in the Operating Manual (Chapter 1, Page 4).

18. The specifications designated TYPE are implicit in the design of the 6960 and are therefore not tested for in the production of the instrument.

19. The specifications designated PRODUCTION are tested for and/or set by adjustment in production. Those PRODUCTION specifications which are also designated (TEST) have their production tests reproduced in the Performance Tests sub-section. Those which are also designated (ADJUSTMENT) are set by adjustments described in the ADJUSTMENT AND CALIBRATION section. (Note that the performance is adjusted to well within the specification).

20.

Table 1 : Performance specifications

SPECIFICATION	DESIGNATION
Power reference (internal calibrator) Power uncertainty : +/-0.7% (traceable to national standard). Power accuracy : +/-1.2% (over one year).	PRODUCTION (ADJUSTMENT)
Instrumentation accuracy Watts mode : +/-0.5% dBm mode : +/-0.02 dB dB REL mode : +/-0.02 dB	PRODUCTION (TEST)
Fast levelling output Levelled power accuracy : +/-0.5% (Excludes CAL and LINEARITY factors) 1 V per range.	TYPE
Recorder output Power accuracy : +/-1.0% dB mode : 1V/decade Watt mode : 5V linear	PRODUCTION (ADJUSTMENT)
Blanking output Max. voltage 25 V, Max. current 50 mA, Open collector, Short circuit for blank.	TYPE
Zero set Zero set error : +/-1.0% of most sensitive range.	PRODUCTION (TEST)
Zero carryover Zero carryover error : 0.03% of full scale when zeroed on most sensitive range.	PRODUCTION (TEST)
Peak Noise Less than 1% of full scale on most sensitive range.	TYPE

Continued overleaf.

Table 1 : Performance specifications (continued)

SPECIFICATION	DESIGNATION
Response time Range 1 : 1s selectable Ranges 2 to 5 : 25 ms using GPIB and trigger modes. 250 ms (display update) selectable.	TYPE

Performance Tests (COVERS ON)

Introduction

21. These tests check the three specifications routinely tested in production which are not directly adjustable by the user: namely **zero set, zero carryover**, and **instrumentation accuracy**. There is a single test combining the zero set and zero carryover specifications.

22. The specifications tested apply to the 6960 only, but in order to test them a Marconi Instruments 6910 or 6920 series RF sensor must be connected to the instrument. Results for both 6910 series and 6920 series sensors are given. It is preferred that a 6910 series detector is used to minimize any possibility of inaccuracies due to drift. If a 6920 series sensor is used, excessive handling and violent temperature changes should be avoided.

23. The format for the tests is:

Specification
Test equipment
Test arrangement
Procedure
Table of results

24. Where a test instrument type number is preceded by "MI", this is a Marconi Instruments product.

25.
Zero set/carryover

SPECIFICATION
Zero set error : +/- 1 % of full scale of range 1.
Zero carryover : +/- 0.03 % of full scale of operative range (when zeroed on most sensitive range).

Test equipment

None required

Test arrangement

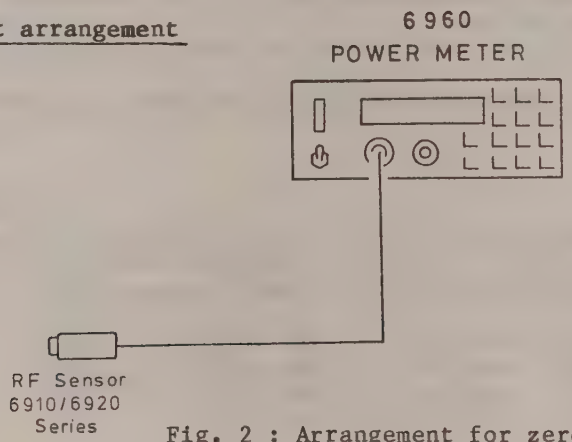


Fig. 2 : Arrangement for zero set/zero carryover test

Procedure

(1) Press [AUTOZERO] and wait until complete.

(2) Set [AVERAGE] to 50, [UNITS] to Watts.

(3) Set [RANGE] to 1.

(4) Wait 15 s for averaging to be completed.

(5) Note zero error reading in the results table, below.

(6) Repeat (3), (4) and (5) for ranges 2 to 5.

(7) Check that zero set/carryover error does not exceed specified limits.

Results

Range	6910 series sensors			6920 series sensors		
	F.S.D.	Error limits	Reading	F.S.D.	Error limits	Reading
1	10 µW	+/- 0.10 µW		0.010 nW	+/- 0.010 nW	
2	100 µW	+/- 0.13 µW		0.013 nW	+/- 0.013 nW	
3	1 mW	+/- 0.4 µW		0.04 nW	+/- 0.04 nW	
4	10 mW	+/- 3.1 µW		0.31 nW	+/- 0.31 nW	
5	100 mW	+/- 30.1 µW		3.01 nW	+/- 3.01 nW	

AUTO [RNG] [-]

26.
Instrumentation accuracy

SPECIFICATION	
Maximum instrumentation error	Watts mode : +/-0.5% dBm mode : +/-0.02 dB dB REL mode : +/-0.02 dB

TEST EQUIPMENT		
Description	Minimum specification	Example(s)
Signal generator	Power accuracy: +/-1 dB (at 50 MHz)	MI 2022 MI 2018A MI 2019A

Test arrangement

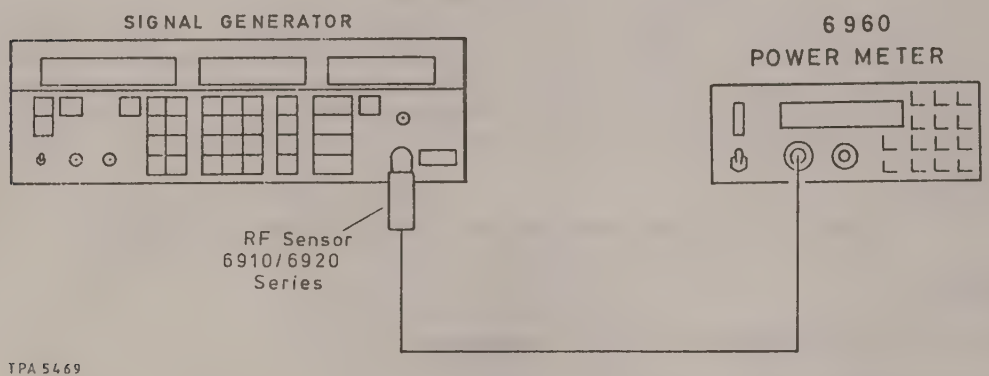


Fig. 3 : Arrangement for instrumentation accuracy test

Procedure (For power reading in Watts mode)

(1) Set signal generator RF level to 0 dBm (-30 dBm for 6920 series), carrier frequency to 50 MHz.

(2) Use signal generator RF on/off control to switch output off.

(3) Press [CAL FACTOR] on 6960 and enter REFERENCE CAL FACTOR (given on all sensors except the 6910 and 6913). For the 6910 and 6913, the default CAL FACTOR of 100 is the correct value, and no entry is normally required.

(4) Press [AUTOZERO] and wait until complete.

(5) Switch signal generator RF output on.

(6) Press [LIN FACTOR] and enter appropriate linearity factor for the sensor being used.

(7) Press [AUTOCAL] and wait until complete. This is indicated by 0 dBm (6910) or -30 dBm (6920) being displayed on the 6960.

(8) Set [UNITS] to Watts, [AVERAGE] to 50.

(9) Set RF level on signal generator to -20 dBm (6910) or -60 dBm (6920).

(10) Set [RANGE] to 1.

(11) Wait 15 s for averaging to be completed.

(12) Note reading ,Pa, in the results table below.

(13) Set [RANGE] to 2.

(14) Wait 15 s.

(15) Note reading, Pb, in the results table below.

(16) Percentage instrumentation error = (Pb/Pa -1) x 100%

(17) Repeat (9) to (16) with the power and range settings shown in the results table.

Results

Initial/Final range	Generator power setting 6910 series	6920 series	Pa (Watts)	Pb (Watts)	% error	Error limit
1/2	-20 dBm	-60 dBm				NOTE (i)
2/3	-10 dBm	-50 dBm				0.5%
3/4	0 dBm	-40 dBm				0.5%
4/5	+10 dBm	-30 dBm				0.5%

NOTES:

(i) At low powers the range error is dominated by noise and zero set (each contributing a possible +/-1%). To accurately measure the range error for ranges 1 and 2 the zero set values for both ranges should be deducted. This, however, is time consuming and susceptible to errors. It is therefore suggested that the instrumentation error for range 1/2 should be tested to 5% only, as a functional check.

(ii) A similar test can be performed to check the instrument accuracy in the dBm and dB REL modes. In this case the instrumentation error would be given by Pb - Pa (dB). The specified maximum error in the dB modes is 0.02 dB (but for ranges 1/2, test for 0.2 dB only).

Internal signal tests (TEST mode) (COVERS OFF)

27. To facilitate fault finding, the 6960 has a "TEST" mode which allows the outputs of the D-A converters and the filter, and the functioning of the display and keyboard to be checked. To enter into TEST mode press RESET and any other key simultaneously. Keep the keys pressed until "tESt" appears on the display, then release. Table 2 shows the tests available. To select the required test, press the appropriate key. To exit from a test (and from TEST mode) press RESET.

Table 2 : TEST mode functions

Key	Test	Display	Test point
0	Display test and filter enable	All displays flash	TP6 wrt TP7
1	Recorder D-A to 0.000 volts	- - - - -	Recorder O/P
2	Recorder D-A to 5.000 volts	- - - - -	Recorder O/P
3	Recorder D-A to 9.99756 volts	- - - - -	Recorder O/P
4	14-bit D-A to Vref (voltage at TP8)	- - - - -	TP10 wrt TP7
	14-bit D-A to zero volts	- - - - -	TP10 wrt TP7
6	14-bit D-A to -Vref x (8191/8192) volts	- - - - -	TP10 wrt TP7
7	Zero D-A to zero (no bits set)	- - - - -	TP12 wrt TP1
8	Zero D-A to centre (MSB only set)	- - - - -	TP12 wrt TP1
9	Zero D-A to top (all bits set)	- - - - -	TP12 wrt TP1
.	Auto-cal (gain) D-A to zero	- - - - -	TP13 wrt TP1
ENT	Auto-cal (gain) D-A to top	- - - - -	TP13 wrt TP1
-	Keyboard test	Display appropriate to key pressed	-

NOTES:

(1) The locations of the test points on AA01 board (together with the preset potentiometers used for adjustments), are shown in Fig. 4, below.

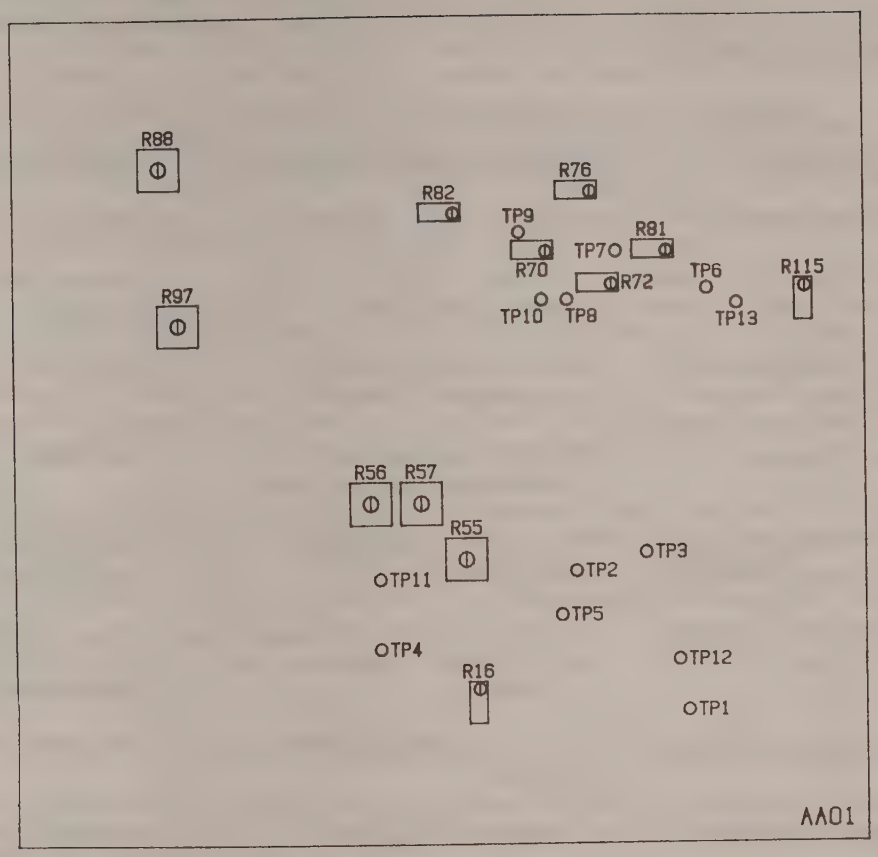
(2) Tests "0" to "6" and "-" give results which are fixed for all 6960's. The other tests are dependent upon individual D-A characteristics and do not yield fixed numerical values. These tests are included as servicing aids.

(3) The expected filter waveform of test "0", and the adjustment procedures required should any of tests "0" to "6" fail, are described in the ADJUSTMENT AND CALIBRATION SECTION

(4) "wrt" means "with respect to".

(5) **IMPORTANT:** Do not ground (earth) any test pins.

28.



Test points

TP1 Analog ground
TP2 Master oscillator
TP3 Spike blanking pulse
TP4 Sample pulse
TP5 Timing control earth
TP6 Detector output
TP7 Chassis earth
TP8 -6.2V reference
TP9 14-bit D-A set-up
TP10 14-bit D-A output
TP11 Time to sample pulse
TP12 Zero D-A output
TP13 Filter input

Preset potentiometers

R16 Master oscillator frequency
R55 Spike blanking width
R56 Time to sample pulse
R57 Sample pulse width
R70 14-bit D-A gain
R72 14-bit D-A offset A
R76 14-bit D-A offset B
R81 Recorder D-A gain
R82 Recorder D-A offset
R88 -19 V set
R97 +5 V set
R115 Filter balance

Fig. 4 : Locations of test points and preset potentiometers on AA01

ADJUSTMENT AND CALIBRATION

29. In this section measurements and adjustments for maintaining the 6960 at its optimum operating condition are described. Table 3 lists the test equipment required.

Table 3 : Test equipment for adjustment and calibration.

Description	Minimum specification	Example
a Multimeter	Greater than 20 kΩ/V	GEC Selectest
b Digital voltmeter	DC volts : 0.1 to 10 V Accuracy 0.001%	Datron 1065
c Counter/timer	Time: 1μs to 1 ms Frequency: 50 MHz	MI 2437
d RF sensor	MI 6910 sensor with calibration certificate	MI 6910
e 50 MHz, 1 mW power reference	Current calibration certificate	Available in MI 6960 or 6950
f 50 MHz rejection filter	Better than 35 dB rejection at 50 MHz. Absorptive at 50 MHz	Specification TE 1031/817 available from MI
g Spectrum analyzer	Coverage to greater than 300 MHz	MI 2382
h Oscilloscope	Bandwidth : 2 MHz Volts/div. : 10 μV to 5 V	Tektronix 5110 with plug-ins 5B40 and 5A22N
i Oscilloscope probe	Differential type	Tektronix P6055
j Oscilloscope	Bandwidth : 70 MHz Volts/div. : 1 V to 5 V	Tektronix 2445
k Oscilloscope probe	To suit above scope	Tektronix P6131
l Filter test jig	Special.	Specification TE 1031/816 available from MI

MI = Marconi Instruments

Voltage checks and adjustments

Test equipment : items b, Digital voltmeter
h, i Oscilloscope and probe

30. 210 V - 250 V range setting. Ensure that the mains supply input voltage selector on the rear panel is set for the above range and that the correct fuses are fitted in FS1 and FS2 (250 mA, time delay). Connect the 6960 to a mains supply of 230 V a.c.

(1) Switch on a.c. supply.

(2) -19 V supply. Locate D32 on AA01, the main p.c.b. Measure the voltage between D32 anode and chassis using the digital voltmeter, (-ve to chassis). Adjust R88 for a reading of -18.9 V to -19.1 V.

(3) Move the digital voltmeter (d.v.m.) positive lead to D35 cathode and check that the voltage lies between +20 V and +21 V.

(4) +5 V supply. Transfer the d.v.m. positive lead to PL6 pin 6. Adjust R97 for +4.95 V to 5.05 V. Remove the d.v.m.

(5) Ripple voltages. Check the ripple voltages on the plus and minus 15 V supply rails and the +5 V rail with respect to the chassis. (+15 V at D35 anode, -15 V at D32 cathode and +5 V at PL6 pin 6). The ripple should be less than 100 mV pk-pk on the +5 V rail and less than 20 mV pk-pk on the other two rails. Use the differential scope probe without connecting the oscilloscope earth to the 6960.

31. 105 V to 120 V range setting. Ensure that the mains supply input voltage selector on the rear panel is set to the above range and that the correct fuses are fitted in FS1 and FS2 (500 mA, time delay). Connect the 6960 to a 115 V a.c. supply then carry out the checks detailed in the previous paragraph.

Timing adjustments

Test equipment : item c, Counter timer

32. Set the counter timer to read time between positive-going edges. Connect the timer input between TP5 (ground) and TP2 (signal). Adjust R16 for a reading of 540 µs ±0.5 µs.

33. Set the counter timer to measure between a positive-going transition and a negative-going transition. Connect to TP3. Adjust R55 for 180 µs ±5 µs.

34. Connect the counter timer to TP11 and adjust R56 for 400 µs ±10 µs.

35. Connect the counter timer to TP4 and adjust R57 for 6.0 µs ±0.5 µs.

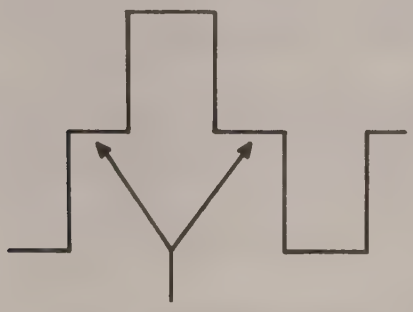
Filter balance adjustment (TEST mode 0)

Test equipment : item 1, Filter test jig
h,i, Oscilloscope and probe

36. This adjustment should not need to be carried out unless AA01 C49, C50 or R115 has been replaced.

37. Connect the special filter test jig as shown on the box. Connect the oscilloscope, a.c. coupled, to TP6 and chassis. Set the sensitivity to 1 mV/div. and time base to 0.5 ms/div. Remove the link from PL7. Enter the 'TEST' mode, see para. 27.

38. Adjust R115 for the waveform shown in Fig. 3.



The two "pedestals" (arrowed) should not differ in voltage by more than 1 mV

Fig. 5 : Filter adjustment

Remove the test jig and oscilloscope. Replace the link on PL7.

14-Bit D-A adjustment (TEST mode 5)

Test equipment : item b, digital voltmeter (d.v.m.)

39. Enter the 'TEST' mode, see para. 27. Connect the d.v.m. negative to TP7 and the positive to TP9. Link together TP7 and TP8.

40. Select test '5' and adjust R72 for a d.v.m. reading of 0 ±3 µV.

41. Connect the d.v.m. positive to TP10 and adjust R76 for 0 ±5 µV.

42. Remove the link from TP8 and adjust R70 for 0 ±10 µV.

43. Remove the d.v.m.

Recorder D-A adjustment (TEST mode 1)

Test equipment : item b, digital voltmeter

44. Enter the 'TEST' mode. Select test '1'. Connect the d.v.m. to the recorder output on the rear panel.

45. Adjust R82 for 0 ±10 µV.

46. Select Test '2' and adjust R81 for 5 V ±100 µV.

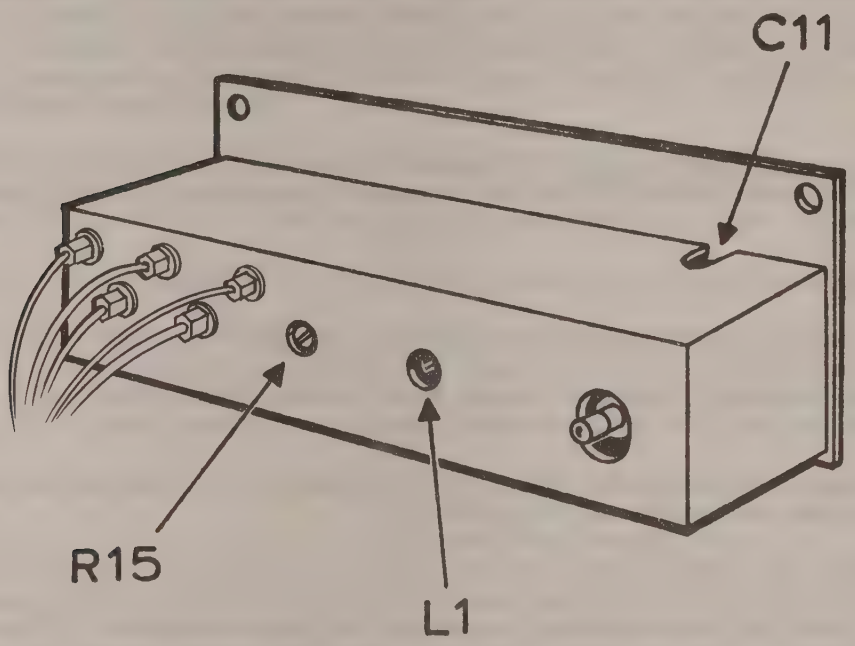


Fig. 6 : AC04, Power reference calibration components

Power reference adjustment

Test equipment : item b, Digital voltmeter
c, Counter timer
d, Sensor 6910
e, 50 MHz, 1 mW power reference
f, High-pass filter
g, Spectrum analyzer

47. Before setting the power reference output level the 6960 should be powered up for at least 15 minutes. The power reference used as a standard should have calibration to a national standard. The tests should be carried out in the correct order. Components referred to are on the power reference assembly.

48. Frequency. Connect the counter timer, set to read frequency, to the power reference output. Adjust the frequency, using L1, to 50 MHz ±50 kHz. Remove the counter timer.

49. Output level (initial setting). Set the 6960 to read 'Watts'. Zero the 6910 Sensor. With the sensor reading the power of the 1 mW power reference standard press 'AUTO CAL'. When the calibration is finished transfer the sensor to the 6960 POWER REFERENCE output and adjust AA05 R15 for 1.000 mW.

50. Harmonics. Harmonic adjustment should not be carried out unless components on the power reference p.c.b. have been changed.

51. Connect the power reference output to the spectrum analyzer via the high-pass filter. Set the analyzer to 175 MHz centre frequency, 20 MHz per division and 0 dBm reference level. Reduce the viewed harmonics to a minimum using C11. No harmonic should be greater than -55 dBm in level. The high-pass filter is used so that the level of 50 MHz signal applied to the mixer in the spectrum analyzer is such that no harmonics are produced by the mixer.

52. Output level (final setting). Repeat "Output level (initial setting)". Ensure that the 6910 Sensor is zeroed correctly before applying any power.

FAULT LOCATION

53. The following section consists of a fault finding table and other checks to aid fault location. To assist fault finding it is advisable to study the technical description in Chap. 4. Note that for AUTO ZERO and AUTO CAL faults the sensor should be tried first as this is the most likely cause.

54. If no other sensor is available, the following tests may be carried out to decide whether the sensor is faulty:-

(i) Enter the TEST mode (see para. 27). Connect a voltmeter to the LEVELLING output on the rear panel. Without the sensor being connected to the power reference output, press the decimal point key followed by the "7" key. The voltage from the levelling output should be between -250 mV and -550 mV for a 6910 series sensor (for a 6920 series sensor, note the voltage). Press the "9" key and check that the voltage is +250 mV to +550 mV for a 6910 series sensor (note the voltage for 6920 series). For a 6920 series sensor, add the two voltages obtained, ignoring the minus sign of the second. The result should be less than 1400 mV. Press the "8" key. The voltage should be less than +/-50 mV for 6910 series sensors, less than +/-200 mV for 6920 series.

(ii) Connect the sensor to the power reference (directly for 6910 series, via a 40 dB attenuator for 6920 series). Check that the voltage is greater than 1.2 V (either type).

(iii) If any of the above voltages are not obtained, the sensor or its cable is likely to be faulty.

55. When disconnecting the Conhex connector from the power reference assembly ensure that the metal clad connector cannot accidentally cause short circuits on the printed boards and create additional faults.

56. The checks given in this chapter are not exhaustive but are intended as a pointer to further investigation. It is emphasized that each fault should be studied having regard for other fault finding information, since incorrect operation of a circuit may be caused by malfunction of an associated circuit.

Power supply faults

57. Symptoms of power supply faults are often confusing therefore it is recommended that the supplies are checked before commencing any other tests. See "Voltage checks and adjustments", above.

58. If the l.e.d. in the +5 V power supply regulator is lit this indicates that the overcurrent circuit has tripped the supply. This may be caused by excessive current being drawn by the processor p.c.b. AA02/1 or the over-voltage s.c.r. firing. To decide in which area the problem lies disconnect the processor p.c.b. and turn on. N.B. The supply to the +5 V regulator must completely disappear before the trip will reset so allow at least 15 seconds before turning on again.

Signal channel faults

59. Before working on a possible signal channel fault it is best if a known good sensor is tried, as failure to AUTO ZERO or AUTOCAL are more likely to be due to the sensor. Various typical waveforms are shown in Fig. 7.

60. Listed below are some possible signal channel problems.

(1) Fault symptom : Sensor will not zero.

Possible faults : Sensor cable faulty, ZERO D-A faulty or loss of one chopper drive

Check : Cable by substitution. Voltage from ZERO D-A goes positive and negative (use TEST mode). Outputs from chopper drivers.

(2) Fault symptom : Failure to AUTO CAL.

Possible faults : Incorrect sample timing. GAIN D-A failed. 14-bit D-A failed.

Check : All timing adjustments as per paras. 32-35. Gain D-A changes the output of the fourth amplifier (IC11b, pin 7) by a factor of 3 when using TEST modes '.' (decimal point) and 'ENT'. 14-bit D-A set-up as per paras. 39-43.

(3) Fault symptom : No signal channel gain.

Possible fault : Faulty amplifier stage.

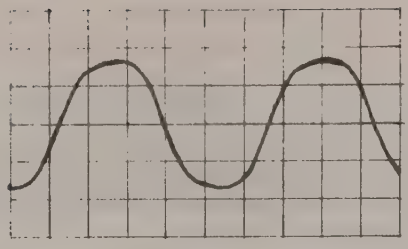
Check : Outputs of each amplifier stage are approximately equal to those shown in Fig. 7.

(4) Fault symptom : Noisy readings on range 1.

Possible fault : (i) Filter not adjusted correctly.
(ii) Inadequate AVERAGE number with 6920 sensor.

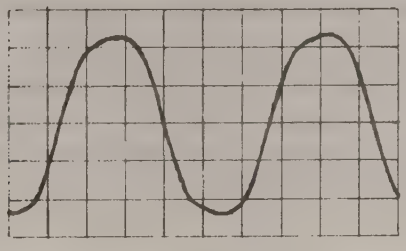
Check : (i) Filter alignment as per paras. 36-38.
(ii) Increase AVERAGE number.

IC1 pin 6
Output first
amplifier



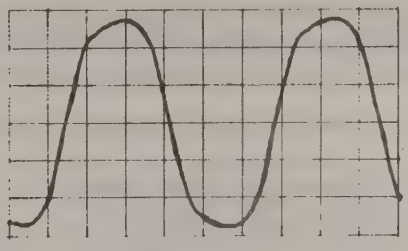
Vertical 20 mV/div.
Horizontal 0.2 ms/div.

IC4b pin 7
Output spike
blanking buffer



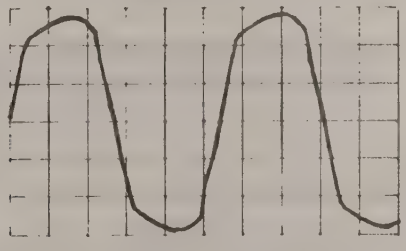
Vertical 20 mV/div
Horizontal 0.2 ms/div.

IC4a pin 1
output second
amplifier



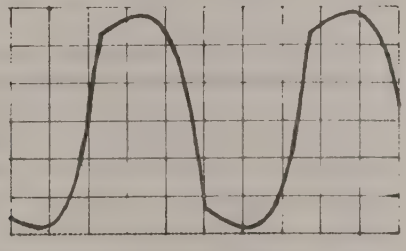
Vertical 0.5 V/div.
Horizontal 0.2 ms/div.

IC11a pin 1
output third
amplifier



Vertical 0.2 V/div.
Horizontal 0.2 ms/div.

IC11b pin 7
output fourth
amplifier
(TP13)



Vertical 0.2 V/div.
Horizontal 0.2 ms/div.

N.B All waveforms taken with 6910 Sensor connected to 0 dBm and 6960 on range 3.

Fig. 7 : Signal channel waveforms

Processor board faults

61. Two possible processor p.c.b. faults are indicated on power-up. If 'Er 1' is displayed on power-up or RESET this indicates that achecksum test on the non-volatile RAM contents has failed. This could be caused by an exhausted battery (B1). The battery voltage should be above 2.0 V to guarantee memory retention.

62. A flashing display on power-up or RESET indicates total failure of the RAM. The signals driving the RAM, IC9, should be checked before changing it.

63. Other processor board faults can show themselves in many different ways. If a fault is suspected on the board and another board (which is known to be working) is available, this should be tried before fault-finding the failing board.

Chapter 6

REPLACEABLE PARTS

CONTENTS

Para.
1 Introduction
3 Abbreviations
4 Component values
6 Ordering
7 Components
7 AA0 - RF power meter with GPIB
8 AA01 - Analogue p.c.b. assembly
9 AA02/1-Processor p.c.b. assembly
10 AA03 - Front panel assembly
11 AA04 - Rear panel assembly
12 AA06 - Ribbon cable 50-way
13 AA07 - Ribbon cable 26-way
14 AA10 - Power link socket
15 AA11 - GPIB interface module
16 AB01 - Keyboard and display assembly
17 AB04 - Cable assembly 6-way
18 AB05 - Cable assembly 2-way
19 AB06 - GPIB p.c.b. assembly
20 AB07 - Switch p.c.b. assembly
21 AB08 - Cable assembly
22 AC03 - Power ref. cable assembly
23 AC04 - Power reference assembly
24 AF03 - Sensor input assembly
25 AF04 - RF cable assembly
26 AF08 - Sensor cable assembly
27 Mechanical parts

Fig. Page
1 Miscellaneous mechanical parts 19/20

INTRODUCTION

1. Each sub-assembly or printed circuit board in this equipment has been allocated a reference designator code, e.g. AA01, AC02 etc.

2. The complete component reference includes its reference designator as a prefix e.g. AA01 C1 (capacitor C1 on printed circuit board AA01) but for convenience in the text and diagrams the prefix is omitted unless it is needed to avoid confusion. However, when ordering replacements or in correspondence the complete component reference must be quoted.

ABBREVIATIONS

3. Electrical components are listed in alpha-numerical order of their complete circuit reference and the following standard abbreviations are used :

ADC	analogue-digital converter
AX	axial
CAP	capacitor
CARR	carrier
CARB	carbon
CC	carbon composition
CDE CNV	code converter
CER	ceramic
CERM	cermet
CF	carbon film
COAX	coaxial
CON	connector
CTR	counter
DAC	digital-analogue converter
DEC/DMX	decoder/demultiplexer
DECOD	decoder
DIL	dual in-line
DIV	divider
DRIV	driver
ELEC	electrolytic
ENCOD	encoder
FEM	female
FF	flip-flop (bistable)
FILTERCON	filtering capacitor
GER	germanium
GP	general purpose
ICA	integrated circuit, analogue
ICD	integrated circuit, digital
IND	inductor
INV	inverter
LD/T	lead through
MF	metal film
MG	metal glaze
MISC	miscellaneous
MO	metal oxide
MP	microprocessor
MP SUPP	microprocessor support
MUX	multiplexer
NET	network
PC	polycarbonate
PETP	(polyester) polyethelene terephthalate
PS	polystyrene
PLL	phase-locked loop

Q/ACT	quick acting
RECT	rectifier
RES	resistor
RV	resistor, variable
RX	receiver
SAPPH	sapphire
SEC	secondary
SCHM	Schmitt
SH REG	shift register
SIL	silicon
SW	switch
T/LAG	time lag
TANT	tantalum
TOG	toggle
TRANS	transistor
TX	transmitter
VAR	variable
VREG	voltage regulator
W	watts at 70°C
WW	wirewound
X	miscellaneous item
XL	crystal
!	static sensitive component
% +	asymmetric tolerance
≠	programmed EPROM

COMPONENT VALUES

4. One or more of the components fitted in the equipment may differ from those listed in this chapter for any of the following reasons :

(a) Components indicated by an * have their values selected during test to achieve particular performance limits.

(b) Owing to supply difficulties, components of different value or type may be substituted provided the overall performance of the equipment is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.

5. When there is a difference between the component fitted and the one listed, always use as a replacement the same type and value as found in the equipment. While equivalent alternatives to some components may be included during manufacture, Marconi Instruments Ltd., Microwave Products Division, should be consulted before any other alternatives are fitted when the equipment is being serviced.

ORDERING

6. When ordering replacements, address the order to our Technical Services Department (address on rear cover) or nearest agent and specify the following for each component required:-

(1) Type≠ and serial number of equipment.

(2) Complete circuit reference.

(3) Description.

(4) Part number

As given on the serial number label at the rear of the equipment; if this is superseded by a model number label, quote the model number instead of the type number. Or contact your local Marconi Instruments, Microwave Products Division representative.

≠ To order a replacement programmed EPROM, specify the serial number of the instrument, and the part number of the IC required. Also specify the EPROM version number, this is identified on the IC following the part number.

COMPONENTS

Circuit ref.	*Description*	*Part no.*
7.	Unit AA0 - RF POWER METER WITH GPIB	
	When ordering, prefix circuit reference with AA0.	
	Complete unit	06960-001
FS1	FUSE T/LAG 0.25A 20X5	23411-055P
FS2	FUSE T/LAG 0.25A 20X5	23411-055P
MP5	SWITCH COVER - VOLTS ADJUST	37590-211G
X21	FUSE T/LAG 0.50A 20X5	23411-056X
X22	CON ASSY FEM 3 FREE CEE22 S	23424-158H
X25	BATTERY PRI 3V LITH 0.4AH	23722-110W
8.	Unit AA01 - ANALOGUE PCB ASSY.	
	Complete unit	06960-010
C1	CAP TANT 47U 6V 20% BEAD	26486-232A
C2	CAP CER 220P 100V 5%	26343-580E
C3	CAP CER 10N 25V 20% DISC	26383-006C
C4	CAP TANT 22U 16V 20% BEAD	26486-230B
C5	CAP TANT 47U 16V 20%	26486-233Z
C6	CAP CER 1N0 100V 5%	26343-583S
C7	CAP TANT 22U 16V 20% BEAD	26486-230B
C8	CAP CER 10N 25V 20% DISC	26383-006C
C9	CAP CER 330P 100V 5%	26343-581G
C10	CAP CER 10N 25V 20% DISC	26383-006C
C11	CAP TANT 1U0 35V 20% BEAD	26486-209F
C12	CAP CER 10N 25V 20% DISC	26383-006C
C13	CAP TANT 1U0 35V 20% BEAD	26486-209F
C14	CAP CER 10N 25V 20% DISC	26383-006C
C15	CAP TANT 1U0 35V 20% BEAD	26486-209F
C16	CAP CER 47N 25V 20% DISC	26383-017U
C17	CAP CER 10N 25V 20% DISC	26383-006C
C18	CAP TANT 1U0 35V 20% BEAD	26486-209F
C19	CAP CER 10N 25V 20% DISC	26383-006C
C20	CAP TANT 1U0 35V 20% BEAD	26486-209F
C21	CAP CER 10N 25V 20% DISC	26383-006C
C22	CAP TANT 1U0 35V 20% BEAD	26486-209F
C23	CAP PETP 220N 63V 10% RAD	26582-406T
C24	CAP CER 1N0 100V 5%	26343-583S
C25	CAP CER 10N 25V 20% DISC	26383-006C
C26	CAP TANT 1U0 35V 20% BEAD	26486-209F
C27	CAP PS 10N0 63V 2% RAD	26538-770T
C28	CAP CER 100P 63V 2% PLATE	26343-477V

Circuit ref.	Description	Part no.
C29	CAP CER 100P 63V 2% PLATE	26343-477V
C30	CAP PS 10N0 63V 2% RAD	26538-770T
C31	CAP CER 330P 100V 5%	26343-581G
C32	CAP CER 100P 63V 2% PLATE	26343-477V
C33	CAP CER 100P 63V 2% PLATE	26343-477V
C34	CAP TANT 22U 16V 20% BEAD	26486-230B
C35	CAP CER 1N0 100V 5%	26343-583S
C36	CAP PETP 220N 63V 10% RAD	26582-406T
C37	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C38	CAP CER 1N0 100V 5%	26343-583S
C39	CAP PETP 220N 63V 10% RAD	26582-406T
C40	CAP CER 10N 25V 20% DISC	26383-006C
C41	CAP TANT 1U0 35V 20% BEAD	26486-209F
C42	CAP CER 10N 25V 20% DISC	26383-006C
C43	CAP TANT 1U0 35V 20% BEAD	26486-209F
C44	CAP CER 10N 25V 20% DISC	26383-006C
C45	CAP TANT 1U0 35V 20% BEAD	26486-209F
C46	CAP CER 10N 25V 20% DISC	26383-006C
C47	CAP TANT 1U0 35V 20% BEAD	26486-209F
C48	CAP CER 470P 100V 5%	26343-582V
C49	CAP PETP 47N 63V 10% RAD MIN	26582-428J
C50	CAP PETP 47N 63V 10% RAD MIN	26582-428J
C51	CAP CER 10N 25V 20% DISC	26383-006C
C52	CAP TANT 1U0 35V 20% BEAD	26486-209F
C53	CAP CER 10N 25V 20% DISC	26383-006C
C54	CAP TANT 1U0 35V 20% BEAD	26486-209F
C55	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C56	CAP CER 10N 25V 20% DISC	26383-006C
C57	CAP CER 10N 25V 20% DISC	26383-006C
C58	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C59	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C60	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C61	CAP CER 100P 63V 2% PLATE	26343-477V
C62	CAP TANT 1U0 35V 20% BEAD	26486-209F
C63	CAP CER 100P 63V 2% PLATE	26343-477V
C64	CAP TANT 1U0 35V 20% BEAD	26486-209F
C65	CAP TANT 1U0 35V 20% BEAD	26486-209F
C66	CAP CER 10N 25V 20% DISC	26383-006C
C67	CAP TANT 1U0 35V 20% BEAD	26486-209F
C68	CAP CER 10N 25V 20% DISC	26383-006C
C69	CAP CER 10N 25V 20% DISC	26383-006C
C70	CAP CER 100P 63V 2% PLATE	26343-477V
C71	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C72	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C73	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C74	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C75	CAP TANT 1U0 35V 20% BEAD	26486-209F
C76	CAP CER 10N 25V 20% DISC	26383-006C
C77	CAP CER 10N 25V 20% DISC	26383-006C
C78	CAP CER 100P 63V 2% PLATE	26343-477V
C79	CAP CER 10N 25V 20% DISC	26383-006C

Circuit ref.	Description	Part no.
C80	CAP CER 10N 25V 20% DISC	26383-006C
C81	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C82	CAP ELEC 4700U 40V 10%+ PCB	26422-321W
C83	CAP CER 1N0 63V 10% PLATE	26383-585M
C84	CAP ELEC 470U 25V 20%+ PCB	26421-129T
C85	CAP ELEC 470U 63V 20%+ PCB	26421-136C
C86	CAP ELEC 470U 25V 20%+ PCB	26421-129T
C87	CAP TANT 22U 35V 20%	26486-231K
C88	CAP TANT 22U 35V 20%	26486-231K
C89	CAP TANT 22U 16V 20% BEAD	26486-230B
C90	CAP TANT 22U 16V 20% BEAD	26486-230B
C91	CAP TANT 22U 16V 20% BEAD	26486-230B
C92	CAP TANT 10U 35V 20% BEAD	26486-225C
C93	CAP TANT 10U 35V 20% BEAD	26486-225C
C94	CAP CER 56P 63V 2% PLATE	26343-474J
C95	CAP CER 47N 25V 20% DISC	26383-017U
C96	CAP CER 1N0 63V 10% PLATE	26383-585M
C97	CAP ELEC 470U 25V 20%+ PCB	26421-129T
C98	CAP ELEC 470U 16V 20%+ PCB	26421-127W
C99	CAP ELEC 470U 20%+ PCB	26421-127W
C100	CAP TANT 1U0 35V 20% BEAD	26486-209F
C101	CAP CER 1N0 63V 10% PLATE	26383-585M
C102	CAP TANT 6U8 6V 20% BEAD	26486-221T
C103	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C104	CAP TANT 1U0 35V 20% BEAD	26486-209F
C105 to C109	CAP CER 100P 100V 10% EMCON 25028 EM 100RD 101K	

Circuit ref.	Description	Part no.
C110 to C113	CAP CHIP 1N0 100V 10% STC : 0805FX7R	
C114	CAP CER 100P 100V 10% EMCON : 5028 EM 100RD 101K	
C115	CAP CER 100P 100V 10% EMCON : 5028 EM 100RD 101K	
C116	CAP CHIP 100P 100V 10% STC : 0805FX7R	
C117	CAP CHIP 100P 100V 10% STC : 0805FX7R	
D1	DI RECT 1N4004 400V	28357-028K
D2	DI RECT 1N4004 400V	28357-028K
D3	DI RECT 1N5401 100V	28355-723N
D4	DI RECT 1N5401 100V	28355-723N
D5	DI SIL 1N4148 75V JUNC	28336-676J
D6	DI SIL 1N4148 75V JUNC	28336-676J
D7	DI ZEN BZX79C 4.7V 5%	28371-371F
D8	DI ZEN BZX79C 5.1V 5%	28371-401U
D9	DI ZEN BZX79C 5.1V 5%	28371-401U
D10	DI SIL 1N4148 75V JUNC	28336-676J
D11	DI SIL 1N4148 75V JUNC	28336-676J
D12	DI ZEN 1N825/A 6.2V 5%	28371-494Z
D13	DI ZEN 1N819 6.2V 5% LOW TC	28371-530K
D14	DI ZEN BZX79C 5.6V 5%	28371-417X
D15	DI BRIDGE KBP608 800V 6A	28359-199B
D16	DI RECT MR810 50V 1A 100NS	28355-167U
D17	DI RECT MR810 50V 1A 100NS	28355-167U
D18	DI RECT MR810 50V 1A 100NS	28355-167U
D19	DI ZEN BZX79C 5.1V 5%	28371-401U
D20	DI ZEN BZX79C4V7 4.7V 5%	28371-371F
D22	DI SIL 1N4148 75V JUNC	28336-676J

Circuit ref.	Description	Part no.
D23	DI RECT 31DQ03 30V SCHOTTKY	28355-169N
D25	DI SIL 1N4148 75V JUNC	28336-676J
D26	DI SIL 1N4148 75 V JUNC	28336-676J
D27	DI SCR BRY55-3 50V 0.8A	28385-711A
D28	DI SIL 1N4148 75V JUNC	28336-676J
D29	LAMP LED YL4484 3V YELLOW	28624-116K
D30	DI ZEN BZX79C 5.6V 5%	28371-417X
D31	DI SCR 2N4441 50V 8A	28385-713H
D32	DI RECT 1N4004 400V	28357-028K
D33	DI RECT 1N4004 400V	28357-028K
D34	DI RECT 1N4004 400V	28357-028K
D35	DI RECT 1N4004 400V	28357-028K
D36	DI RECT 1N4004 400V	28357-028K
D37	DI SIL 1N4148 75V JUNC	28336-676J
IC1	ICA AMP OP27GZ ULTRA LOW NOISE	28461-368T
IC2	ICA AMP OP27GZ ULTRA LOW NOISE	28461-368T
IC3	ICA SW HI3-201-5 QUAD !	28461-934Z
IC4	ICA AMP OP14CP DUAL MATCHED	28461-367D
IC5	ICD MONO 4047 AST MULTI BI !	28468-307C
IC6	ICD MONO 4047 AST MULTI BI !	28468-307C
IC7	ICD MONO 4538 DUAL RETR PREC !	28468-313K
IC8	ICD NAND 4011 QUAD 2INP BI !	28466-340R
IC9	ICD FF D 4013 DUAL BI !	28462-608A
IC10	ICA SW HI3-201-5 QUAD !	28461-934Z
IC11	ICA AMP TL072CP DUAL FET I/P	TEXAS
IC12	ICA DAC AD7543JN 12BIT MULT !	28461-931B
IC13	ICA AMP TL072CP DUAL FET I/P	28461-348Z
IC14	ICA SW HI3-201-5 QUAD !	28461-934Z
IC15	ICA AMP TL072CP DUAL FET I/P	28461-348Z
IC16	ICA SW HI3-201-5 QUAD !	28461-934Z
IC17	ICA COMP LM311N DIL8	28461-695U
IC18	AMP TL072CP DUAL FET I/P	28461-348Z
IC19	ICA DAC AD7543JN 12BIT MULT !	28461-931B
IC20	ICA AMP TL072CP DUAL FET I/P	28461-348Z
IC21	ICA DAC HS3140C-4 14BIT MULT !	28461-932K
IC22	ICA AMP OP27GZ ULTRA LOW NOISE	28461-368T
IC23	ICA AMP OP27GZ ULTRA LOW NOISE	28461-368T
IC24	ICA DAC AD7543JN 12BIT MULT !	28461-931B
IC25	ICA AMP TL071CP FET I/P DIL8	28461-347A
IC26	ICA VREG 78S40 SMPS CTRL DIL16	28461-729E
IC27	ICA VREG+ 7815 15V 1A TO220	28461-709S
IC28	ICA VREG- 7915 15V 1A TO220	28461-735N
IC29	ICA VREG UA723C PROG DIL14	28461-706F
L1	IND CHOKE S.M.P.S.	44190-043H
L6	IND CHOKE 1UH 10% MINIATURE	23642-419V
PL1	CON PCB HDR 50WAY FXD STRT	23435-953T
PL2	CON PCB MALE 6WAY FXD FR LOCK	23435-871N
PL3	CON PART M/W MALE 2W HOUSG 12A	23435-538D
PL4	CON PCB MALE 6WAY FXD FR LOCK	23435-871N
PL5	CON PCB MALE 8WAY FXD FR LOCK	23435-872L

Circuit ref.	Description	Part no.
PL6	CON PART M/W FEM 9W HOUSG 9A	23435-520K
PL7	CON PCB MALE 36 FXD STRAIGHT	23435-121J
R1	RES MF 47K 1/4W 2% 100PPM	24773-313H
R2	RES MF 10K 1/4W 2% 100PPM	24773-297M
R3	RES MF 4K7 1/4W 0.5% 50PPM	24753-484H
R4	RES MF 56K 1/4W 2% 100PPM	24773-315U
R5	RES MF 39K 1/4W 2% 100PPM	24773-311A
R6	RES MF 80K6 1/4W .5% 50PPM	24753-349U
R7	RES MF 100R 1/4W 2% 100PPM	24773-249J
R8	RES MF 100R 1/4W 2% 100PPM	24773-249J
R9	RES MG 10M 1/4W 5%	24321-885W
R10	RES MF 470R 1/4W 2% 100PPM	24773-265M
R11	RES WW 150R 1.5W 5%	25123-054V
R12	RES MF 100K 1/4W 2% 100PPM	24773-321L
R13	RES MF 10K 1/4W 2% 100PPM	24773-297M
R14	RES MF 24K75 .6W .01% .6PPM	24722-006S
R15	RES MF 250R .6W .01% .6PPM	24722-001L
R16	RV CERM 5K0 LIN 1/2W 10%	25748-563F
R17	RES MF 22K 1/4W 2% 100PPM	24773-305R
R18	RES MF 68K 1/4W 2% 100PPM	24773-317N
R19	RES MF 33K 1/4W 2% 100PPM	24773-309Z
R20	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R21	RES MF 10K 1/4W 2% 100PPM	24773-297M
R22	RES MF 2K05 1/4W .5% 50PPM	24753-350H
R23	RES MF 48K7 1/4W .5% 50PPM	24753-351E

Circuit ref.	Description	Part no.
R24	RES MF 22K5 .6W .01% .6PPM	24722-005V
R25	RES MF 2K25 .6W .01% .6PPM	24722-002J
R26	RES MF 250R .6W .01% .6PPM	24722-001L
R27	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R28	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R29	RES MF 680R 1/4W 2% 100PPM	24773-269K
R30	RES MF 1K15 1/4W .5% 50PPM	24753-352U
R31	RES MF 38K3 1/4W .5% 50PPM	24753-353Y
R32	RES NET 100K 5% 15DIL	24681-508P
R33	RES MF 100K 1/4W 2% 100PPM	24773-321L
R34	RES MF 20K .6W .01% .6PPM	24722-004G
R35	RES MF 10K .6W .01% .6PPM	24722-003F
R36	RES MF 10K .6W .01% .6PPM	24722-003F
R37	RES MF 20K5 1/4W .5% 50PPM	24753-354N
R38	RES MF 40K2 1/4W .5% 50PPM	24753-355L
R39	RES MF 20K0 1/4W 0.5% 50PPM	24753-663N
R40	RES MF 20K0 1/4W 0.5% 50PPM	24753-663N
R41	RES MF 10K 1/4W 2% 100PPM	24773-297M
R42	RES MF 20K .6W .01% .6PPM	24722-004G
R43	RES MF 22K 1/4W 2% 100PPM	24773-305R
R44	RES MF 22K 1/4W 2% 100PPM	24773-305R
R45	RES MF 3K9 1/4W 2% 100PPM	24773-287V
R46	RES MF 22K 1/4W 2% 100PPM	24773-305R
R47	RES MF 22K 1/4W 2% 100PPM	24773-305R
R48	RES MF 3K9 1/4W 2% 100PPM	24773-287V

Circuit ref.	Description	Part no.
R49	RES MF 100R 1/4W 2% 100PPM	24773-249J
R50	RES MF 100R 1/4W 2% 100PPM	24773-249J
R51	RES MF 100R 1/4W 2% 100PPM	24773-249J
R52	RES MF 100R 1/4W 2% 100PPM	24773-249J
R53	RES MF 10K 1/4W 2% 100PPM	24773-297M
R54	RES MF 6K8 1/4W 2% 100PPM	24773-293D
R55	RV CERM 10K LIN .5W 10% HORZ	25711-641G
R56	RV CERM 50K LIN .5W 10% HORZ	25711-643S
R57	RV CERM 5K0 LIN .5W 10% HORZ	25711-640F
R58	RES MF 820K 1/4W 2% 100PPM	24773-344Z
R59	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R60	RES MF 4K3 1/4W 2% 100PPM	24773-288S
R61	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R62	RES MF 1K05 1/4W .5% 50PPM	24753-360F
R63	RES MF 10K 1/4W 2% 100PPM	24773-297M
R64	RES MF 20K 1/4W 2% 100PPM	24773-304C
R65	RES MF 10K 1/4W 2% 100PPM	24773-297M
R66	RES MF 3K9 1/4W 2% 100PPM	24773-287V
R67	RES MF 330R 1/4W 2% 100PPM	24773-261D
R68	RES MF 20K 1/4W 2% 100PPM	24773-304C
R69	RES MF 3K92 1/4W 0.5% 50PPM	24753-567S
R70	RV CERM 200R LIN 1/2W 10%	25748-567W
R71	RES MF 4K02 1/4W 0.5% 50PPM	24753-627Y
R72	RV CERM 10K LIN 1/2W 10%	25748-566S
R73	RES NET 100K 5% 15DIL	24681-508P
R74	RES MF 665R 1/4W .5% 50PPM	24753-361G
R75	RES MF 1K8 1/4W 2% 100PPM	24773-279N
R76	RV CERM 10K LIN 1/2W 10%	25748-566S
R77	RES MF 130R 1/4W 2% 100PPM	24773-252J
R78	RES MF 33K 1/4W 2% 100PPM	24773-309Z
R79	RES MF 62K 1/4W 2% 100PPM	24773-316Y
R80	RES MF 33K 1/4W 2% 100PPM	24773-309Z
R81	RV CERM 10K LIN 1/2W 10%	25748-566S
R82	RV CERM 10K LIN 1/2W 10%	25748-566S
R83	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R84	RES MF 0R33 0.4W 5% 300PPM	24783-001A
R85	RES MF 180R 1/4W 2% 100PPM	24773-255V
R86	RES MF 3K3 1/4W 2% 100PPM	24773-285F
R87	RES MF 43K 1/4W 2% 100PPM	24773-312Z
R88	RV CERM 10K LIN .5W 10% HORZ	25711-641G
R89	RES MF 470R 1/2W 2% 250PPM	24573-065J
R90	RES MF 24K 1/4W 2% 100PPM	24773-306B
R91	RES MF 15R 1/4W 2% 100PPM	24773-229X
R92	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R93	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R94	RES MF 1K5 1/2W 2% 250PPM	24573-077X
R95	RES MF 330R 1/4W 2% 100PPM	24773-261D
R96	RES MF 68K 1/4W 2% 100PPM	24773-317N
R97	RV CERM 10K LIN .5W 10% HORZ	25711-641G
R98	RES MF 1K5 1/2W 1% 100PPM	24763-853C
R99	RES MF 18R 1/4W 2% 100PPM	24773-231P
R100	RES MF 10K 1/4W 2% 100PPM	24773-297M

Circuit ref.	*Description*	*Part no.*
R101	RES MF 10K 1/4W 2% 100PPM	24773-297M
R102	RES MF 180R 1/4W 2% 100PPM	24773-255V
R103	RES MF 100K 1/4W 2% 100PPM	24773-321L
R104	RES MF 100K 1/4W 2% 100PPM	24773-321L
R105	RES MF 0R47 0.4W 5% 300PPM	24783-002Z
R106	RES MF 0R47 0.4W 5% 300PPM	24783-002Z
R107	RES MF 100R 1/4W 2% 100PPM	24773-249J
R108	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R109	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R110	RES MF 1K2 1/4W 2% 100PPM	24773-275H
R111	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R112	RES MF 9K1 1/4W 2% 100PPM	24773-296X
R113	RES MF 12K 1/4W 2% 100PPM	24773-299R
R114	RES MF 820R 1/4W 2% 100PPM	24773-271B
R115	RV CERM 10K LIN 1/2W 10%	25748-566S
R116	RES MF 13K 1/4W 2% 100PPM	24773-300T
R117	RES MF 5K6 1/4W 2% 100PPM	24773-291S
SK7	CON JUMP FEM 2 1 ROW	23435-990X
TR1	TR NSI D44C6 45V 50M - PWR	28455-301Y
TR2	TR PSI BC307A 45V 130M - GEN	28435-227H
TR3	TR NSI 2N2369 15V 500M - SW	28452-197H
TR4	TR PSI BC307A 45V 130M - GEN	28435-227H
TR5	TR NSI 2N2369 15V 500M - SW	28452-197H
TR6	TR NSI BC209C 20V 150M - GEN	28452-771P
TR7	TR PSI MPSL08 12V 700M - SW	28431-767E
TR8	TR NSI BC209C 20V 150M - GEN	28452-771P
TR9	TR NSI 2N2222A 40V 300M - GEN	28454-802F
TR10	TR NMF IRF 521 60V 8A	28459-047P
TR11	TR NSI BC209C 20V 150M - GEN	28452-771P
TR12	TR PSI BC307A 45V 130M - GEN	28435-227H
TR13	TR PSI BC307A 45V 130M - GEN	28435-227H
TR14	TR PSI BC307A 45V 130M - GEN	28435-227H
X25	S/C-ACC WASHER 6BA/M3 INSUL	28488-127P
X26	S/C-ACC BUSH M3 INSUL	28488-134R
X29	CON PART M/W PIN NO DETENT PCB	23435-567V

9. Unit AA02/1-PROCESSOR PCB ASSY.

When ordering, prefix circuit reference with AA02.

	Complete unit	06960-011
C1	CAP PETP 100N 63V 10% RAD MIN	26582-429F
C2	CAP TANT 2U2 35V 20% BEAD	26486-214V
C3	CAP PETP 100N 63V 10% RAD MIN	26582-429F
C4	CAP ELEC 100U 35V 20%+ PCB	26421-122J
C5	CAP TANT 2U2 35V 20% BEAD	26486-214V

Circuit ref.	Description	Part no.
C6	CAP TANT 10U 35V 20% BEAD	26486-225C
C7	CAP TANT 47U 6V 20% BEAD	26486-232A
C8	CAP TANT 1U0 35V 20% BEAD	26486-209F
C9	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C10	CAP TANT 1U0 35V 20% BEAD	26486-209F
C11	CAP TANT 1U0 35V 20% BEAD	26486-209F
C12	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C13	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C14	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C15	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C16	CAP CER 100P 63V 2% PLATE	26343-477V
C17	CAP TANT 22U 16V 20% BEAD	26486-230B
C18	CAP TANT 1U0 35V 20% BEAD	26486-209F
C19	CAP TANT 1U0 35V 20% BEAD	26486-209F
D1	DI ZEN BZX79C4V7 4.7V 5%	28371-371F
D2	DI SIL 1N4148 75V JUNC	28336-676J
D3	DI SIL 1N4148 75V JUNC	28336-676J
D4	DI RECT 1N4004 400V	28357-028K
D5	DI SIL 1N4148 75V JUNC	28336-676J
D6	DI SIL 1N4148 75V JUNC	28336-676J
D7	DI SIL 1N4148 75V JUNC	28336-676J
D8	DI SIL 1N4148 75V JUNC	28336-676J
D9	DI SIL 1N4148 75V JUNC	28336-676J
D10	DI SIL 1N3595 150V JUNC	28337-556N
D11	DI H/CARR 1N5711	28349-007E
IC1	ICD MONO 4538 DUAL RETR PREC !	28468-313K
IC2	ICD NAND 4093 QUAD 2INP SCH BI !	28469-207J
IC3	ICD MP P8085A-2 8 BIT NMOS !	28469-415F
IC4	ICD LATCH 74LS373 OCT 3ST	28462-410E
IC5	ICD BUFF 74LS245 OCT TXRX	28469-188B
IC6	ICD FF D 74LS74 DUAL +EDG TR	28462-611A
IC7	ICD DEC/DMX 74LS138 3-8	28465-027F
IC8	ICD PROM ASSY (Type 2764)	28471-014H
IC9	ICD RAM UPD446D-1 2KX8 250NS !	28469-311L
IC10	ICD NAND 74LS00 QUAD 2INP	28466-345H
IC11	ICD AND 74LS08 QUAD 2INP	28466-012L
IC12	ICD MP SUP 8255A-5 PRG PER INT !	28467-010T
IC13	ICD MP SUP 8255A-5 PRG PER INT !	28467-010T
PL1	CON PCB HDR 50WAY FXD STRT	23435-953T
PL2	CON PCB HDR 20WAY FIXD STRT	23435-951W
PL3	CON PCB HDR 26WAY FXD STRT	23435-952D
R1	RES MF 22K 1/4W 2% 100PPM	24773-305R
R2	RES MF 10K 1/4W 2% 100PPM	24773-297M
R3	RES MF 270K 1/4W 2% 100PPM	24773-331D
R4	RES MF 82K 1/4W 2% 100PPM	24773-319J
R5	RES MF 27K 1/4W 2% 100PPM	24773-307K
R6	RES MF 22K 1/4W 2% 100PPM	24773-305R

X1 = LCD LUCIO 291N-03BF MADE IN U.K. 864301

PART MARKING

Circuit ref.	Description	Part no.
R7	RES MF 100K 1/4W 2% 100PPM	24773-321L
R8	RES MF 100R 1/4W 2% 100PPM	24773-249J
R9	RES MF 10K 1/4W 2% 100PPM	24773-297M
R10	RES MF 22K 1/4W 2% 100PPM	24773-305R
R11	RES MF 22K 1/4W 2% 100PPM	24773-305R
R12	RES MF 47K 1/4W 2% 100PPM	24773-313H
R13	RES MF 10K 1/4W 2% 100PPM	24773-297M
R14	RES MF 10K 1/4W 2% 100PPM	24773-297M
R15	RES MF 10K 1/4W 2% 100PPM	24773-297M
R16	RES MF 10K 1/4W 2% 100PPM	24773-297M
R17	RES MF 6K8 1/4W 2% 100PPM	24773-293D
R18	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R19	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R20	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R21	RES MF 100K 1/4W 2% 100PPM	24773-321L
R22	RES MF 33K 1/4W 2% 100PPM	24773-309Z
R23	RES MF 22K 1/4W 2% 100PPM	24773-305R
S1	SW PUSH 1P1W MOM LIPA D6	23465-301P
S2	SW SLIDE 4 x 2W 28V DIL QUAD	23467-307C
TR1	TR NSI 2N2369 15V 500M - SW	28452-197H
TR2	TR NSI 2N2369 15V 500M - SW	28452-197H
X10	S/C ACC SKT DIL28 LOW PROFILE	28488-045L
X11	S/C ACC PAD TO18,ETC TO .1" GRD	28488-115L
XL1	XTAL 10M P30P 20R	28312-047U

10. Unit AA03 - FRONT PANEL ASSY

When ordering, prefix circuit reference with AA03.

Circuit ref.	Description	Part no.
	Complete unit	06960-002
D1	LAMP LED YL4484 3V YELLOW	28624-116K
S1	SW TOG 2C0 LEVER MAINS	23462-249Z
X1	DISPLAY LCD CUSTOM HAMLIN	06960-040/
X21	MOUNT, LAMP	37590-247D
X35	EDGE METER 200UA 750R	06960-034/

11. Unit AA04 - REAR PANEL ASSY

When ordering, prefix circuit reference with AA04.

Circuit ref.	Description	Part no.
	Complete unit	06960-003
PL1	CON PWR MALE 3 FXD RF FILTER	23423-150L
S1	SW SLIDE 2C0 PANEL MTG	23467-161W

Circuit ref.	*Description*	*Part no.*
SK1	CON RF BNC FEM 50 BKHD INS	23443-449Y
SK2	CON RF BNC FEM 50 BKHD INS	23443-449Y
SK3	CON RF BNC FEM 50 BKHD INS	23443-449Y
T1	TRANSFORMER MAINS	06960-044/
X21	H/W FUSE HOLDER PANEL 20X5	23416-192R
X22	H/W COVER FOR 23416-192/193	23416-198E
X23	CON PART PWR COVER INS PVC BLK	23423-999Y

12. Unit AA06 - RIBBON CABLE ASSY 50 WAY

When ordering, prefix circuit reference with AA06.

	Complete unit	06960-005
SK1	CON IDC FEM 50 FREE P+STR/REL	23435-848T
SK2	CON IDC FEM 50 FREE P+STR/REL	23435-848T

13. Unit AA07 - RIBBON CABLE ASSY 26 WAY

When ordering, prefix circuit reference with AA07.

	Complete unit	06960-006
SK1	CON IDC FEM 26 FREE P+STR/REL	23435-847D
SK2	CON IDC FEM 26 FREE P+STR/REL	23435-847D

Circuit ref.	*Description*	*Part no.*

14. Unit AA10 - POWER LINK SOCKET ASSY

When ordering, prefix circuit reference with AA10.

	Complete unit	06960-013
X24	CON PART M/W MALE 9W HOUSG 9A	23435-539T
X25	CON PART M/W SKT+DIMPLE CRIMP	23435-591E

15. Unit AA11 - GPIB INTERFACE MODULE (Optional accessory)

When ordering, prefix circuit reference with AA11.

	Complete unit	03964-650
SK1	CON 57 FEM 24 FXD PCB EDG GPIB	23435-133X

16. Unit AB01 - KEYBOARD & DISPLAY PCB ASSY

When ordering, prefix circuit reference with AB01.

	Complete unit	06960-012
C1	CAP CER 56P 63V 2% PLATE	26343-474J
C2	CAP CER 100N 50V 20% M/LAYER	26383-534Y
C3	CAP CER 100N 50V 20% M/LAYER	26383-534Y

Circuit ref.	*Description*	*Part no.*
IC1	ICD DRIV HLCD-0438 LCD SER IN !	28467-016B
IC2	ICD DRIV HLCD-0438 LCD SER IN !	28467-016B
PL1	CON PCB HDR 26 WAY FXD STRT	23435-952D
R1	RES NET 4K7 5% 15DIL	24681-510T
R2	RES MF 4K7 1/4W 2% 100PPM	24773-289W
S1	SW PUSH 1P1W MOM LIPA D6	23465-301P
S2	SW PUSH 1P1W MOM LIPA D6	23465-301P
S3	SW PUSH 1P1W MOM LIPA D6	23465-301P
S4	SW PUSH 1P1W MOM LIPA D6	23465-301P
S5	SW PUSH 1P1W MOM LIPA D6	23465-301P
S6	SW PUSH 1P1W MOM LIPA D6	23465-301P
S7	SW PUSH 1P1W MOM LIPA D6	23465-301P
S8	SW PUSH 1P1W MOM LIPA D6	23465-301P
S9	SW PUSH 1P1W MOM LIPA D6	23465-301P
S10	SW PUSH 1P1W MOM LIPA D6	23465-301P
S11	SW PUSH 1P1W MOM LIPA D6	23465-301P
S12	SW PUSH 1P1W MOM LIPA D6	23465-301P
S13	SW PUSH 1P1W MOM LIPA D6	23465-301P
S14	SW PUSH 1P1W MOM LIPA D6	23465-301P
X10	S/C ACC SKT SIL25 W/WRAP SNAP	28488-172A

Circuit ref.	*Description*	*Part no.*
17.	Unit AB04 - CABLE ASSY 6 WAY	
	When ordering, prefix circuit reference with AB04.	
	Complete unit	06960-015
SK1	CON PART M/W 6 WAY HOUSING POL	23435-921T
X2	CON PART MIN CRIMP TERML 4809	23435-930B
18.	Unit AB05 - CABLE ASSY 2 WAY	
	When ordering, prefix circuit reference with AB05.	
	Complete unit	06960-014
SK1	CON PART M/W FEM 2W HOUSG 12A	23435-519Z
X1	CON PART M/W SKT+DIMPLE CRIMP	23435-591E
19.	Unit AB06 - GPIB PCB ASSY (Optional accessory)	
	When ordering, prefix circuit reference with AB06.	
	Complete unit	03964-301
C1	CAP CER 10N 25V 20% DISC	26383-006C
C2	CAP CER 10N 25V 20% DISC	26383-006C

Circuit ref.	Description	Part no.
C3	CAP CER 10N 25V 20% DISC	26383-006C
C4	CAP CER 10N 25V 20% DISC	26383-006C
C5	CAP CER 10N 25V 20% DISC	26383-006C
C6	CAP CER 10N 25V 20% DISC	26383-006C
C7	CAP CER 10N 25V 20% DISC	26383-006C
C8	CAP TANT 47U 6V 20% BEAD	26486-232A
IC1	ICD MP SUP 8291A GPIB TALK/LIS !	28467-014C
IC2	ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC3	ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC4	ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC5	ICD BUFF 3448 QUAD GPIBTXRX 3S	28469-190R
IC6	ICD NAND 74LS00 QUAD 2INP	28466-345H
IC7	ICD BUFF 74LS365A HEX 3ST	28469-194Z
R1	RES NET 4K7 2% 7SIP	24681-608D
R7	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R8	RES MF 4K7 1/4W 2% 100PPM	24773-289W

20. Unit AB07 - SWITCH PCB ASSY

When ordering, prefix circuit reference with AB07.

	Complete unit	03964-302
S1	SW ROCKER 2C0 6SW DIL	23465-897N

21. Unit AB08 - CABLE ASSY

When ordering, prefix circuit reference with AB08.

	Complete unit	03964-601
PL1	CON PCB S/TRANS 20 FXD IDC	23435-860R
SK1	CON IDC FEM 20 FREE P+STR/RLF	23435-845S

22. Unit AC03 - POWER REF CABLE ASSY

When ordering, prefix circuit reference with AC03.

	Complete unit	06950-012
X26	CON PCB FEM 6W FREE SELF LOCK	23435-521A
X27	CON PART M/W 6WAY HOUSING POL	23435-921T
X28	CON PART MIN CRIMP TERML 4809	23435-930B

23. Unit AC04 - POWER REFERENCE ASSY

When ordering, prefix circuit reference with AC04.

	Complete unit	06950-100

Circuit ref.	*Description*	*Part no.*
C1	CAP CER 100N 100V 20%+ M/LAYER	26383-532E
C2	CAP CER 33P 63V 5% PLATE	26343-471Y
C3	CAP CER 18P 63V 5% PLATE	26343-468Y
C4	CAP CER 18P 63V 5% PLATE	26343-468Y
C5	CAP CER 100P 63V 2% PLATE	26343-477V
C6	CAP CER 1N0 63V 10% PLATE	26383-585M
C7	CAP CER 100N 100V 20%+ M/LAYER	26383-532E
C8	CAP CER 1N0 63V 10% PLATE	26383-585M
C9	CAP CER 100N 100V 20%+ M/LAYER	26383-532E
C10	CAP CER 18P 63V 5% PLATE	26343-468Y
C11	CAP VAR PLAS 22P 2P TRIM	26878-407U
C12	CAP CER 100P 63V 2% PLATE	26343-477V
C13	CAP CER 1N0 63V 10% PLATE	26383-585M
C14	CAP TANT 1U0 35V 20% BEAD	26486-209F
C15	CAP TANT 1U0 35V 20% BEAD	26486-209F
C16	CAP CER 47N 25V 20% DISC	26383-017U
C17	CAP CER 100N 100V 20%+ M/LAYER	26383-532E
C18	CAP CER 100N 100V 20%+ M/LAYER	26383-532E
D1	DI SIL 1N4148 75V JUNC	28336-676J
D2	DI H/CARR 1N5711	28349-007E
D3	DI H/CARR 1N5711	28349-007E
D4	DI SIL 1N4148 75V JUNC	28336-676J
IC1	ICA AMP Op14CP DUAL MATCHED	28461-367D

Circuit ref.	*Description*	*Part no.*
L1	COIL ASSY	06950-105/
L2	IND CHOKE 0.1UH 10% MINIATURE	23642-418G
L3	IND CHOKE 0.1UH 10% MINIATURE	23642-418G
MP1	BOX	06950-104/
PL1	CON PCB MALE 6W FXD SELF LOCK	23435-543P
R1	RES MF 10K 1/4W 2% 100PPM	24773-297M
R2	RES MF 10K 1/4W 2% 100PPM	24773-297M
R3	RES MF 10K 1/4W 2% 100PPM	24773-297M
R4	RES MF 47K 1/4W 2% 100PPM	24773-313H
R5	RES MF 120K 1/4W 2% 100PPM	24773-323F
R6	RES MF 47K 1/4W 2% 100PPM	24773-313H
R7	RES MF 220R 1/4W 2% 100PPM	24773-257W
R8	RES MF 270R 1/4W 2% 100PPM	24773-259T
R9	RES MF 10K 1/4W 2% 100PPM	24773-297M
R10	RES MF 220K 1/4W 2% 100PPM	24773-329T
R11	RES MF 59R0 1/4W .5% 50PPM	24753-358G
R12	RES MF 141R 1/4W 0.5% 50PPM	24753-437P
R13	RES MF 8R6 1/4W 0.5% 50PPM	24753-407M
R14	RES MF 220K 1/4W 2% 100PPM	24773-329T
R15	RV CERM 5K LIN .3W 10% FLAT	25748-506P
R16	RES MF 13K3 1/4W .5% 50PPM	24753-359V
R17	RES MF 10K 1/4W 2% 100PPM	24773-297M
R18	RES MF 49K9 1/4W 0.5% 50PPM	24753-346Z
R19	RES MF 49K9 1/4W 0.5% 50PPM	24753-346Z

Circuit ref.	*Description*	*Part no.*
R20	RES MF 7K5 1/4W 2% 100PPM	24773-294T
SK1	CON RF SMB MALE 50 PCB ELBOW	23444-359Z
TR1	TR NSI BC 208B 20V 150M - GEN	28452-781A
TR2	TR NSI MPSA13 125M - DAR	28453-842U
TR3	TR NMF 40673 20V 400M DG	28459-010V

24. Unit AF03 - SENSOR INPUT ASSY

When ordering, prefix circuit reference with AF03.

	Complete unit	06950-016
SK10	CON CIRC FEM 12 FXD HEX NUT	23424-521S

25. Unit AF04 - RF CABLE ASSY

When ordering, prefix circuit reference with AF04.

	Complete unit	06950-005
SK1	CON RF SMB FEM 50 FREE ELBOW	23444-336L

Circuit ref.	*Description*	*Part no.*

26. Unit AF08 - SENSOR CABLE ASSEMBLY

When ordering, prefix circuit reference with AF08.

	Complete unit	06950-039
PL1	CON CIRC MALE 12 FREE	23423-520Z
PL2	CON CIRC MALE 12 FREE	23423-520Z

MECHANICAL PARTS

27. Item numbers refer to Fig. 1.

Item no.	*Description*	*Part no.*
1	Top cover	35904-009F
2	Side rail, 1 of 2	34900-747N
3	Flange, 1 of 2	37590-221X
4	Spring washer, 1 of 2	31119-045W
5	Arm, 1 of 2	37590-222M
6	Rear foot, 1 of 2	37590-505Z
7	Cap, 1 of 2	37590-219M
8	Boss, 1 of 2	37590-220P
9	Handle assembly	41700-239W
10	Rear frame	35890-072W
11	Bottom cover	35904-010L
12	Pushbutton set	06960-041/
13	Push cover natural, 1 of 13	37590-298U
14	Keycap, orange	06960-039/
15	Front frame	35890-083B
16	Stud, 1 of 4	37590-223C
17	Foot, 1 of 4	37590-224R

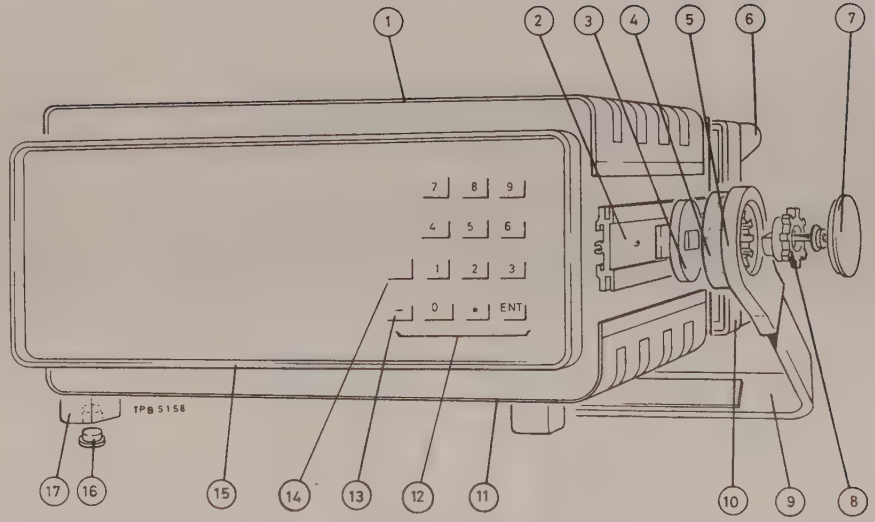


Fig. 1 Miscellaneous mechanical parts

Chapter 7

SERVICING DIAGRAMS

CONTENTS

Para.

1 Circuit notes
1 Component values
3 Symbols

Fig.	*Drawing No.*	*Unit*	*Title*	*Page*
1a	6960/050	AA01	Component layout	4
1	6960/010	AA01	Analogue p.c.b. assembly, 1 of 4 ...	5
2a	6960/050	AA01	Board detail	6
2	6960/900	AA01	Analogue p.c.b. assembly, 2 of 4 ...	7/8
3	6960/900	AA01	Analogue p.c.b. assembly, 3 of 4 ...	9/10
4	6960/900	AA01	Analogue p.c.b. assembly, 4 of 4 ...	11
5a	6960/032	AA02/1	Component layout	12
5	6960/903	AA02/1	Processor p.c.b. assembly, 1 of 2	13
6a	6960/032	AA02/1	Board detail	14
6	6960/901	AA02	Processor p.c.b. assembly, 2 of 2 ..	15
7a	6960/052	AB01	Component layout and board detail ..	16
7	6960/902	AB01	Power meter, keyboard and display assembly	17
8a	6950/102	AC04	Component layout and board detail ..	18
8	6950/901	AC04	Power reference assembly	19
9a	3964/315	GPIB	Component layout and board detail ..	20
9	3964/921	GPIB	Interface module	21/22

CIRCUIT NOTES

Component values

1. Resistors : Code letter R = ohms, k = kilohms (10^3), M = megohms (10^6).

   Capacitors : Code letter m = millifarads (10^{-3}), μ = microfarads (10^{-6}), n = nanofarads (10^{-9}), p = picofarads (10^{-12}).

   Inductors : Code letter H = henrys, m = millihenrys (10^{-3}), μ = microhenrys (10^{-6}), n = nanohenrys (10^{-9}).

   SIC : Value selected during test, nominal value shown.

2. Components are marked normally with two, three or four figures according to the accuracy limit ±10%, ±1% or ±0.1%. The code letter used indicates the multiplier and replaces the decimal point. Because a marking 4m7 could be interpreted as milliohms, millifarads or millihenrys, all values are placed near to its related symbol.

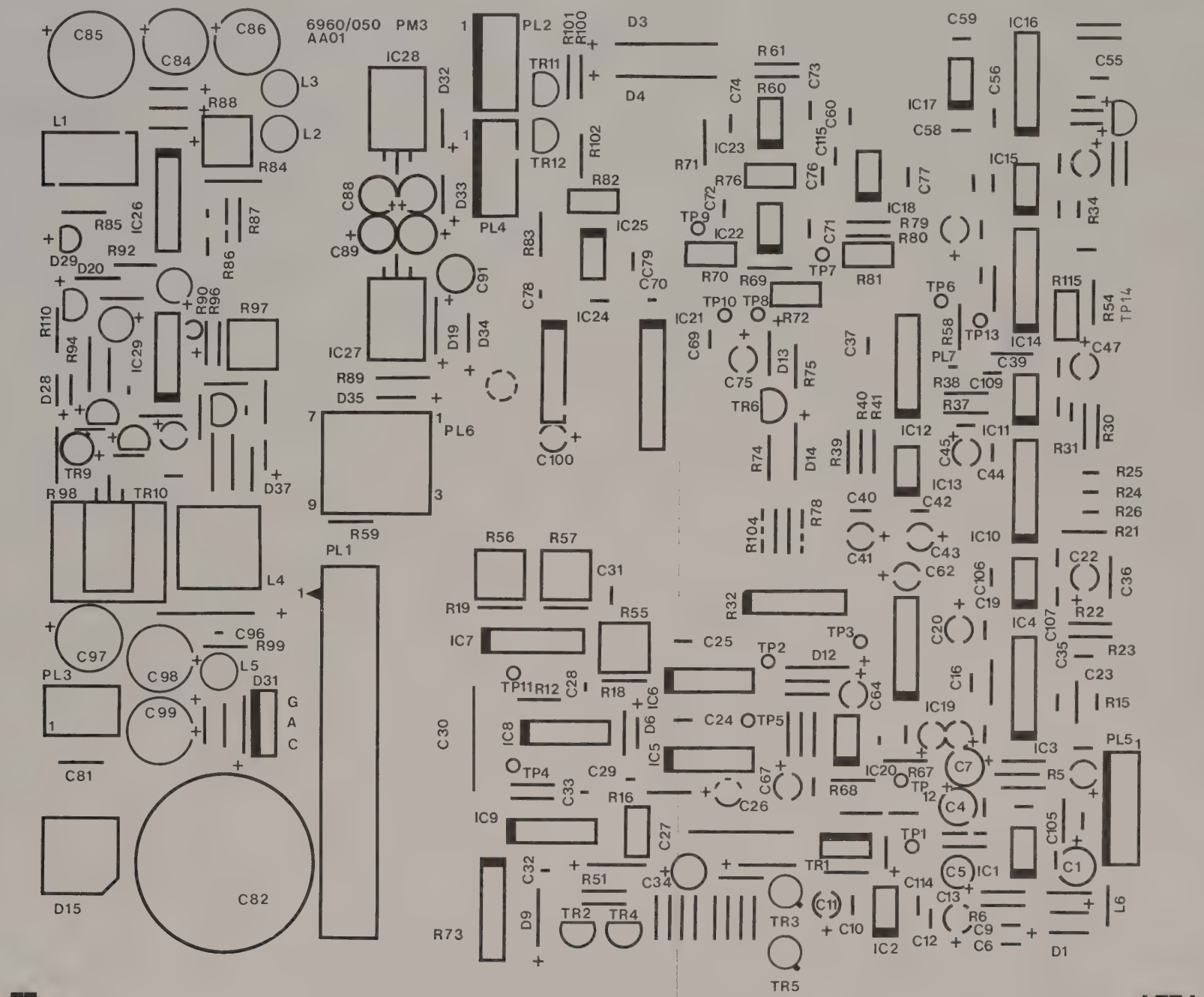
Symbols

3. Symbols are based on the provisions of BS 3939 with the following additions :

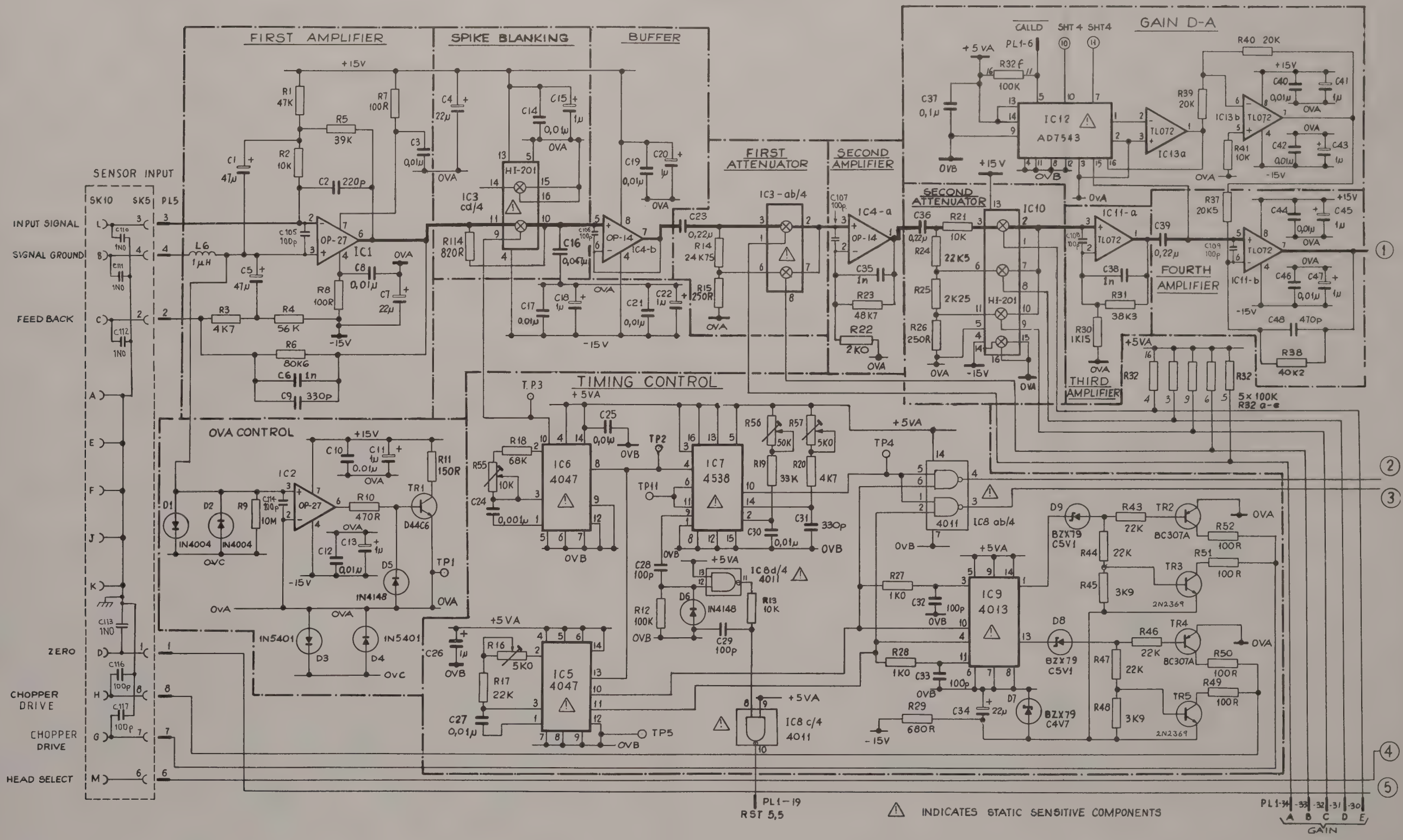
Edge connector

Warning, see Notes and Cautions.

Test point



Component layout : AA01

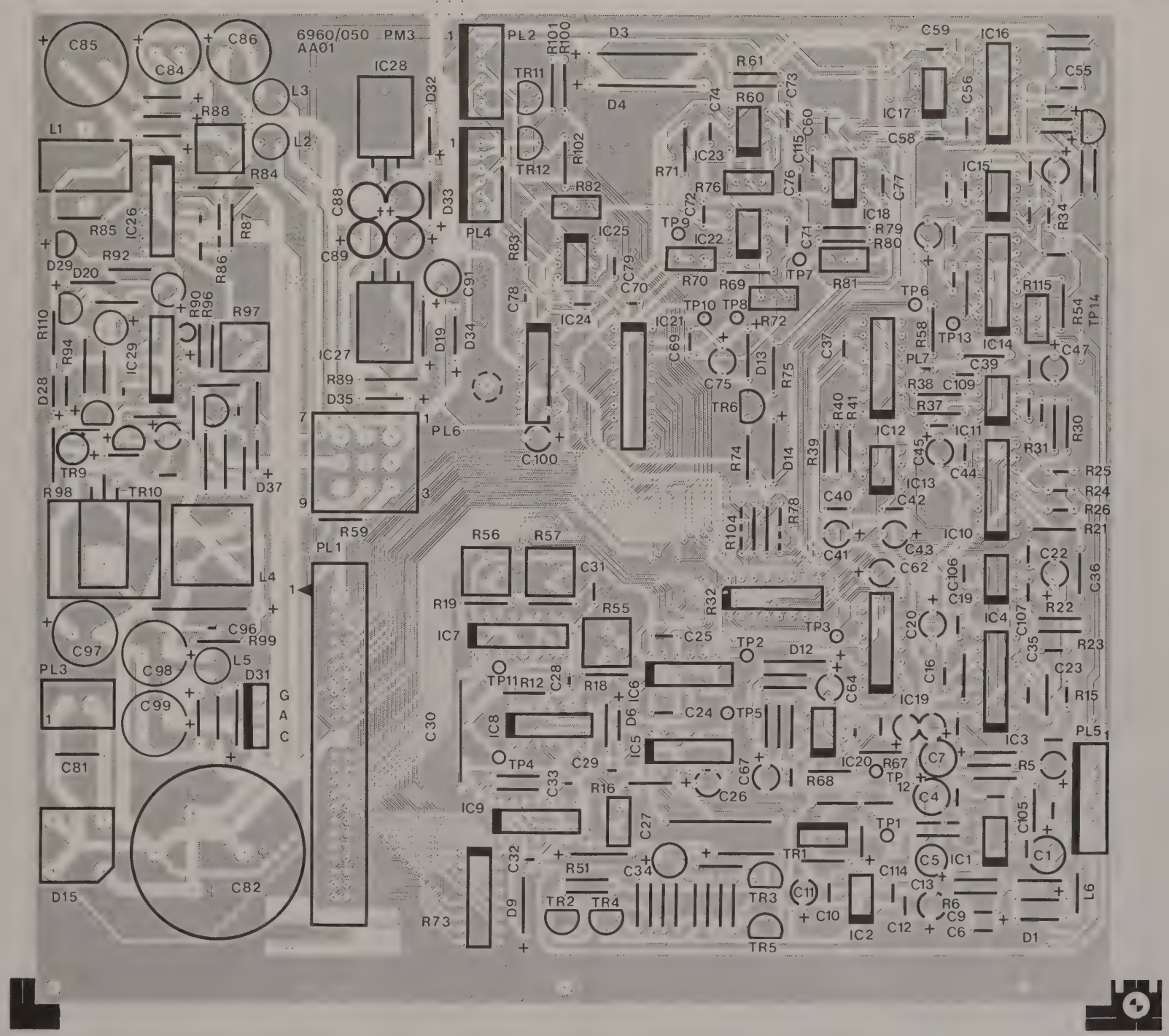


Drg. No. 6960/900 Sht. 1 of 4, Iss. 2

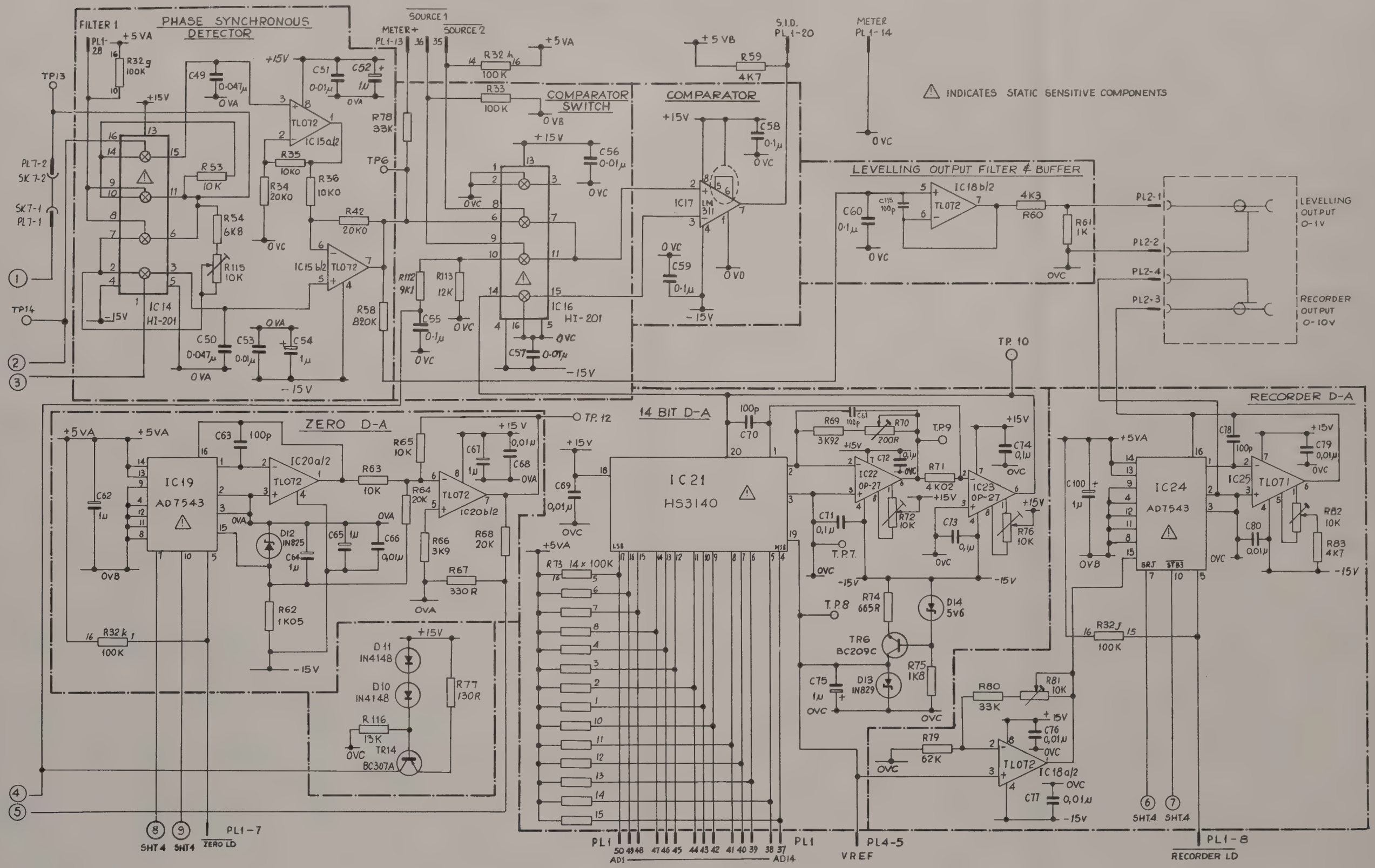
AA01 : Analogue p.c.b. assembly

Fig. 1

Apr. 87 (Am. 3)



Board detail : AA01

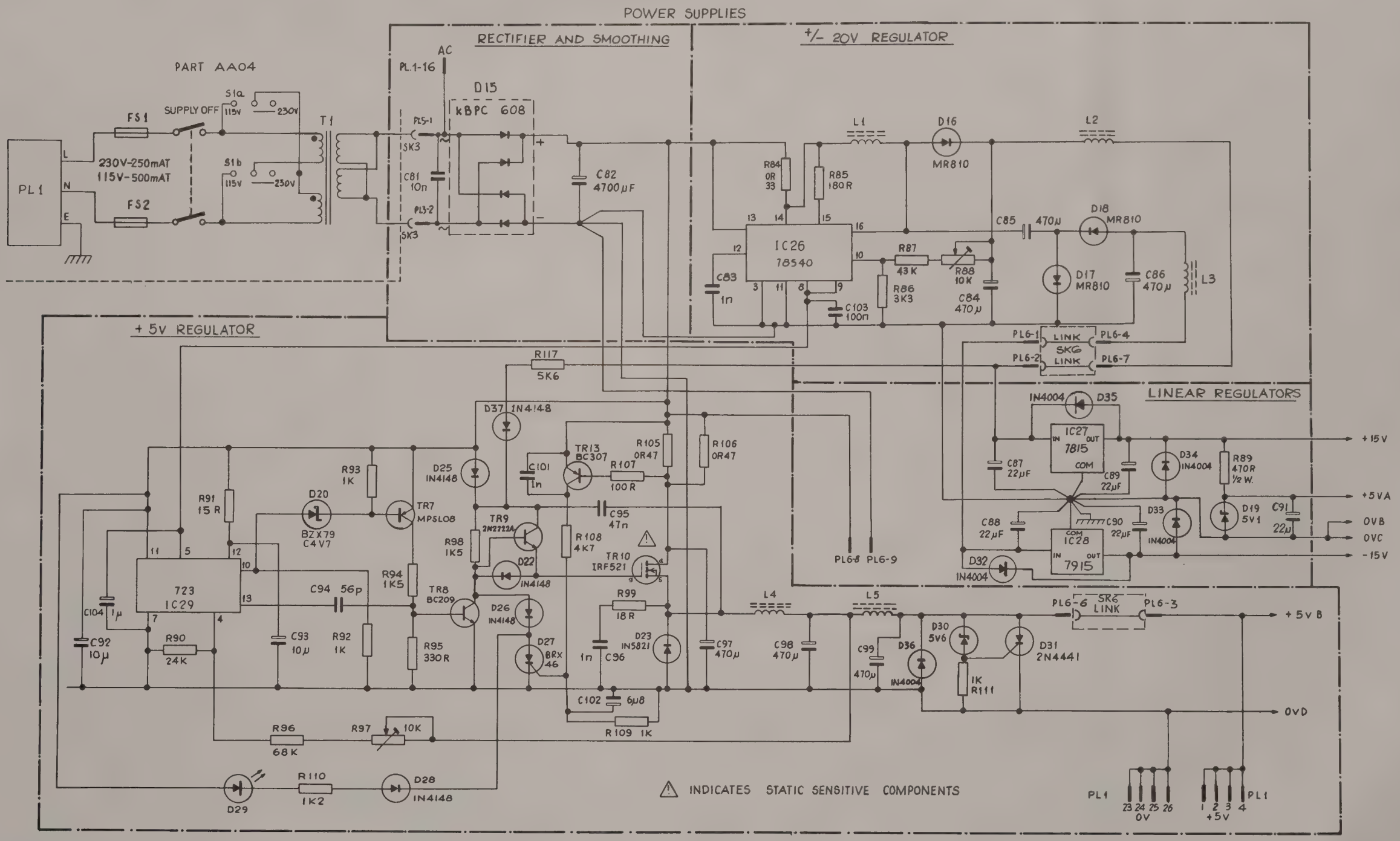


AA01 : Analogue p.c.b. assembly

Drg. No. 6960/900 Sht. 2 of 4, Iss. 1

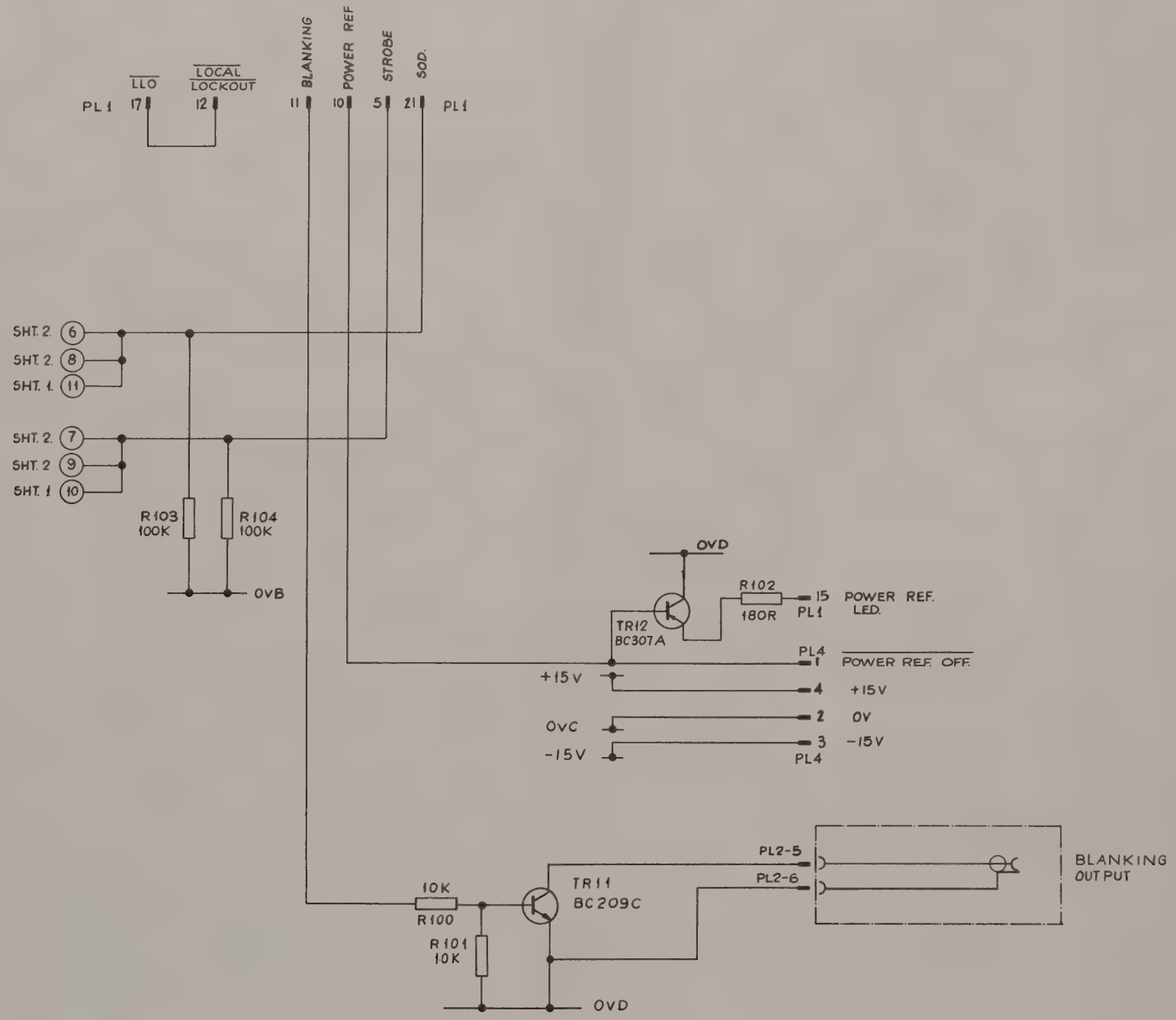
Fig. 2

Apr. 87 (Am. 3)



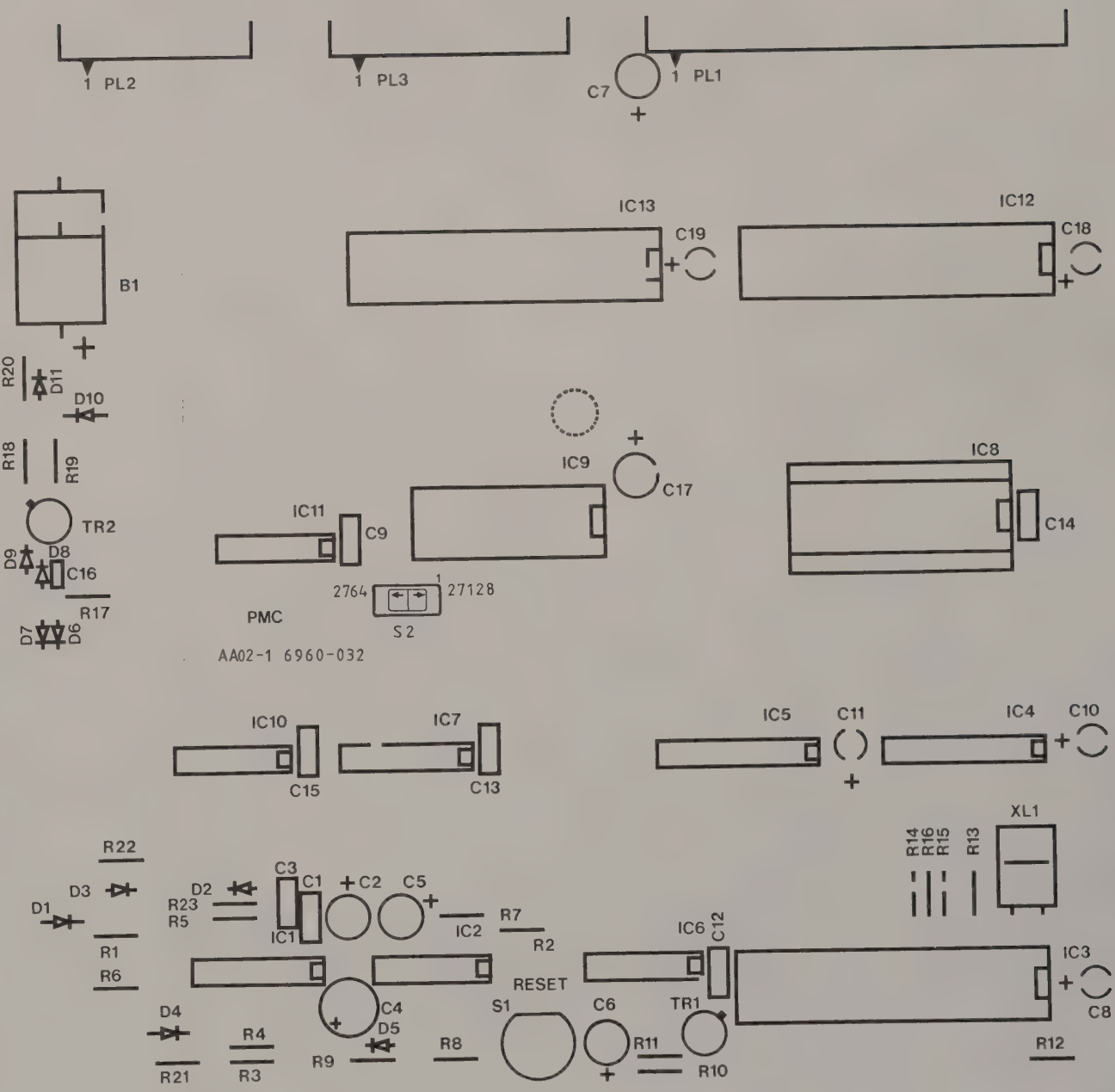
Drg. No. 6960/900 Sht. 3 of 4, Iss. 4

AA01 : Analogue p.c.b. assembly



AA01 : Analogue p.c.b. assembly

Drg. No. 6960/900 Sht. 4 of 4, Iss. 1



Component layout : AA02/1

RESET CONTROL

⚠ INDICATES STATIC SENSITIVE COMPONENT

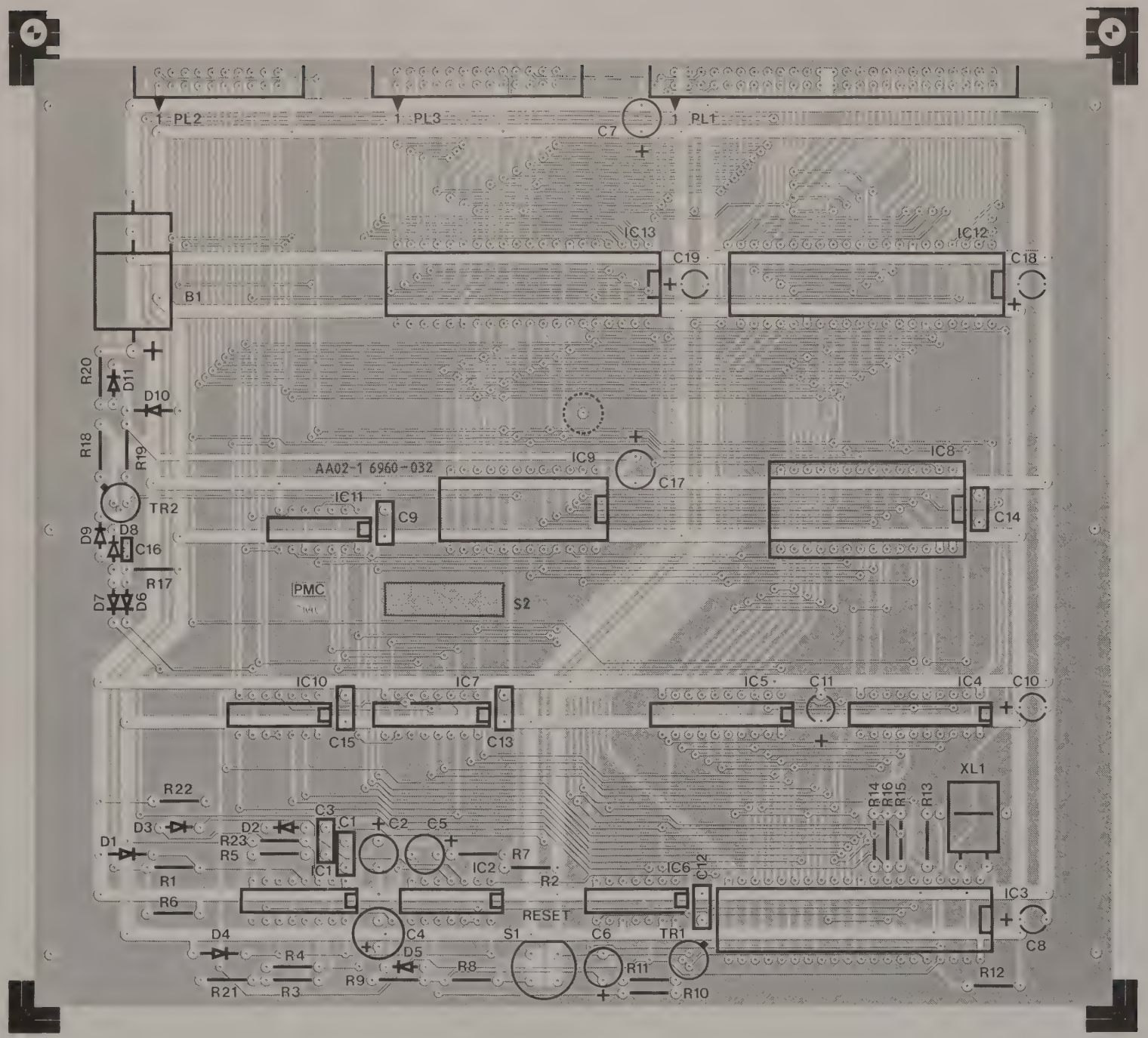
ADDRESS DECODING

POS	CS1	CS2	CS3	CS4	CS5	CS6	CS7
2764	0-0FFFH	1000H-1FFFH	2000H-2FFFH	3000H-3FFFH	4000H-4FFFH	5000H-5FFFH	6000H-6FFFH
27128	0-1FFFH	2000H-3FFFH	4000H-5FFFH	6000H-7FFFH	8000H-9FFFH	0A000H-0BFFFH	0C000H-0DFFFH

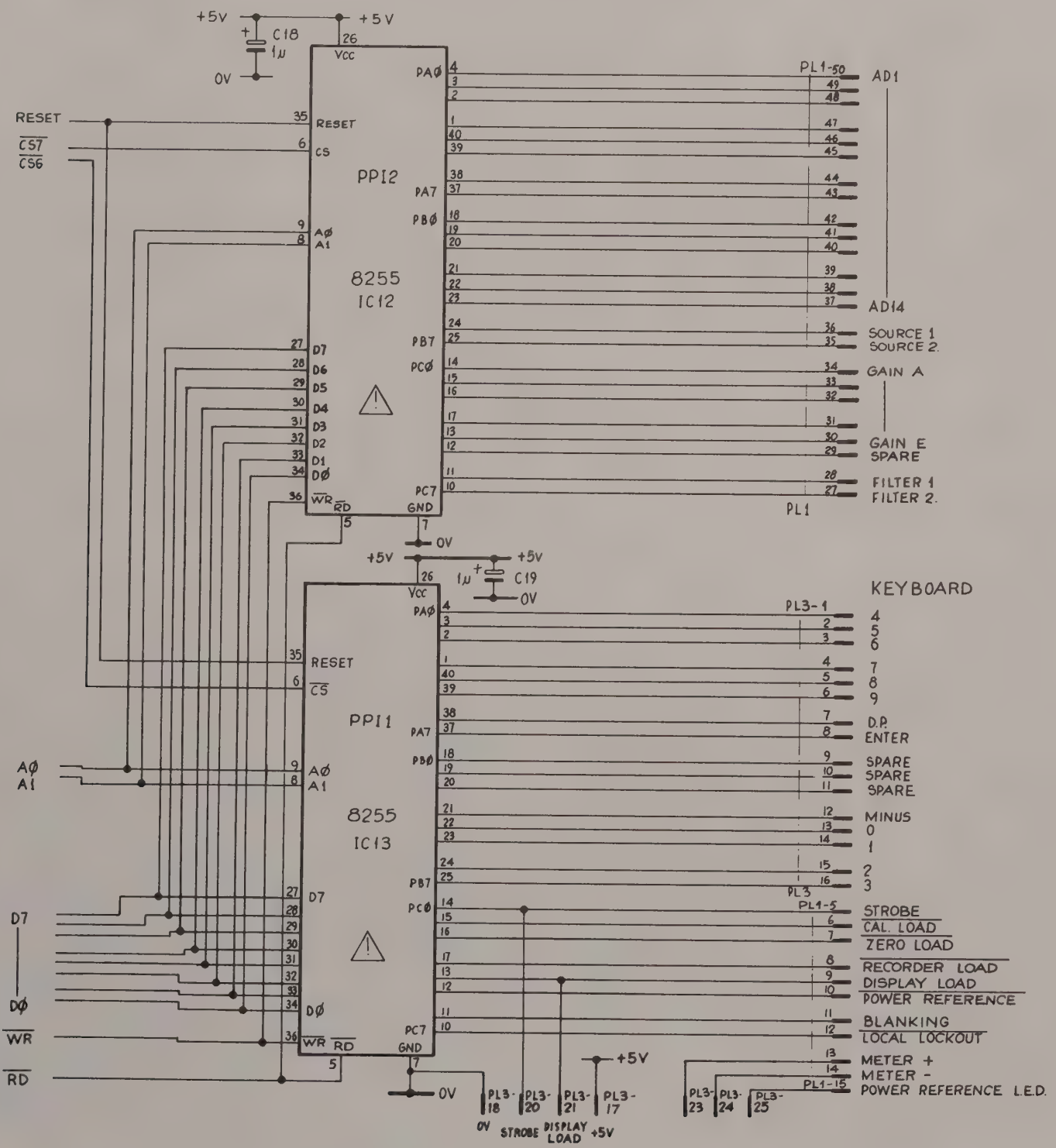
AA02/1 : Processor p.c.b. assembly

Drg. No. 6960/903 Sht. 1 of 2, Iss. 1

Fig. 5



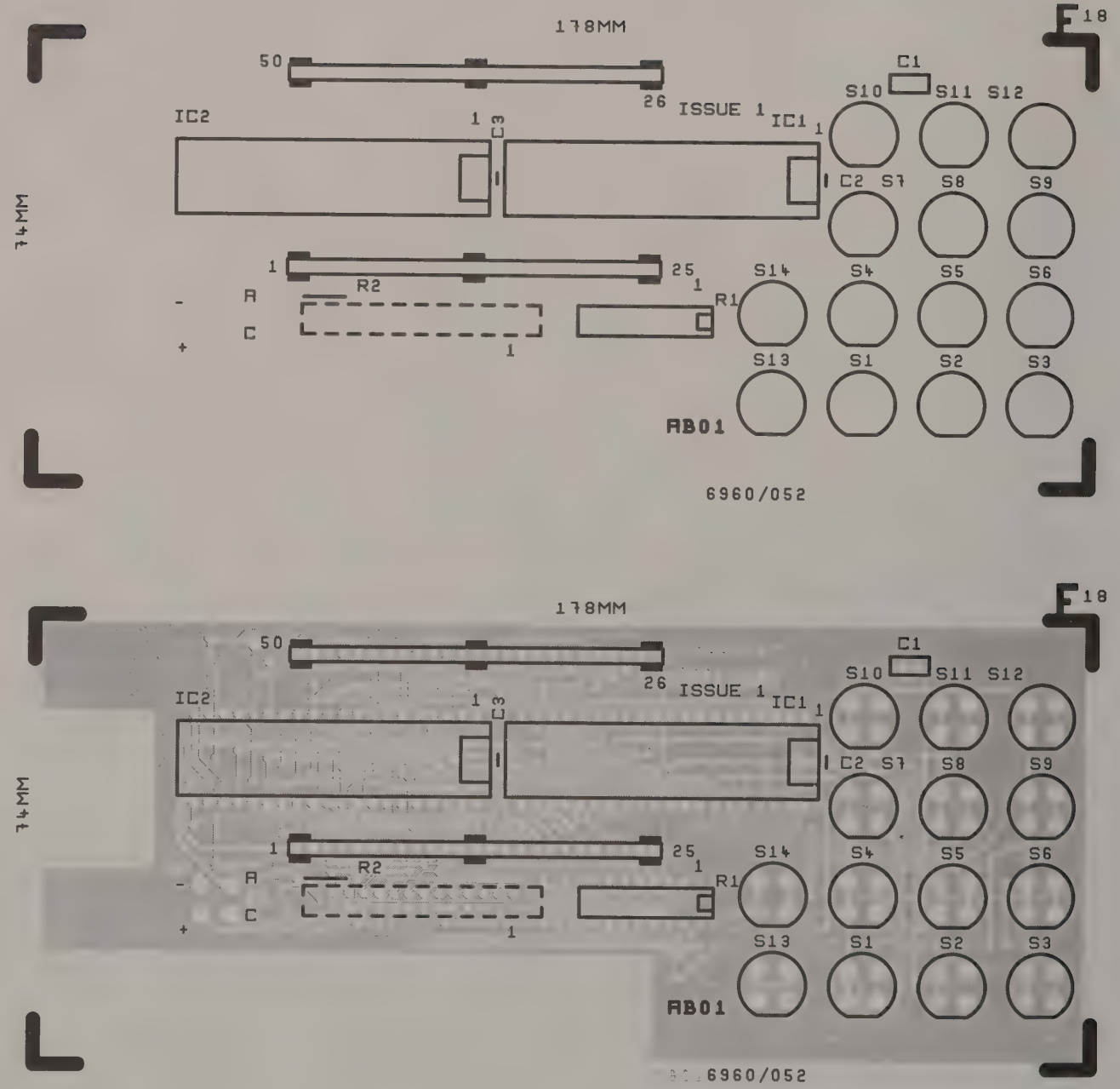
Board detail : AA02/1



⚠ INDICATES STATIC SENSITIVE COMPONENTS

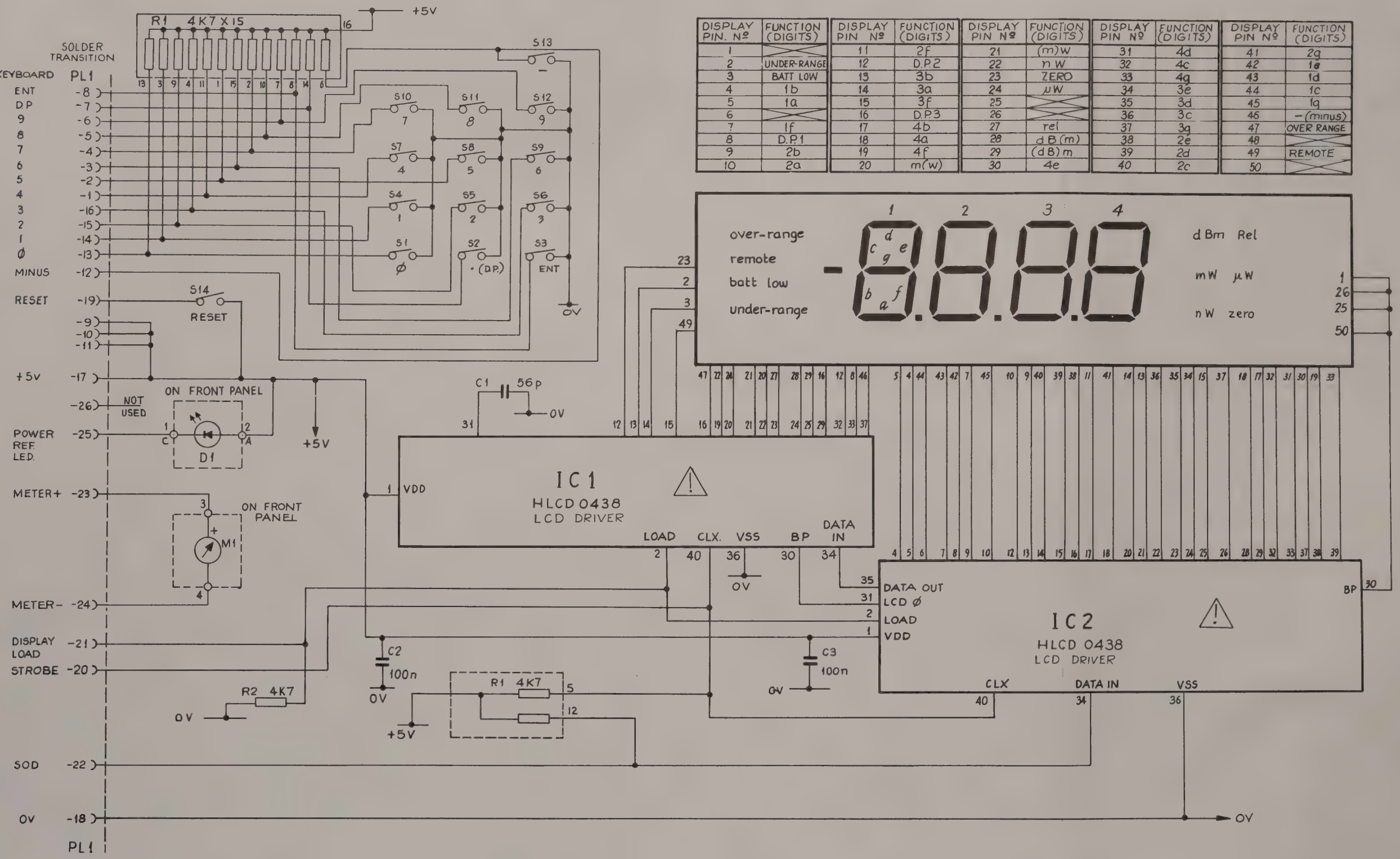
Drg. No. 6960/903 Sht. 2 of 2 , Iss. 1

AA02/1 : Processor p.c.b. assembly



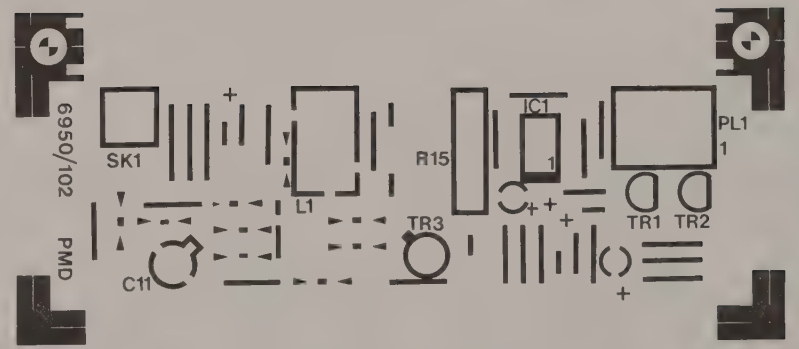
Component layout and board detail : AB01

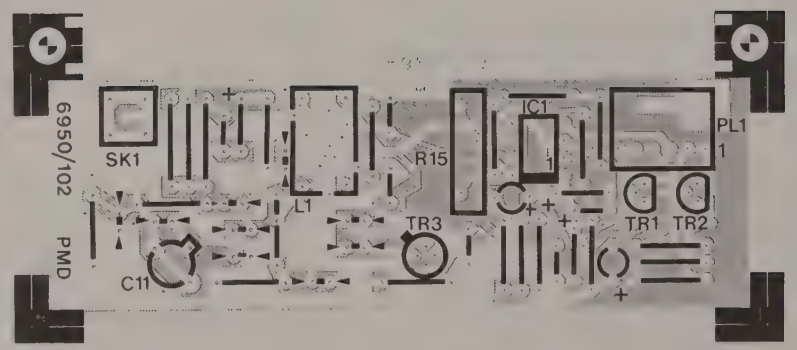
DISPLAY PIN. Nº	FUNCTION (DIGITS)	DISPLAY PIN Nº	FUNCTION (DIGITS)	DISPLAY PIN Nº	FUNCTION (DIGITS)	DISPLAY PIN Nº	FUNCTION (DIGITS)	DISPLAY PIN Nº	FUNCTION (DIGITS)
1		11	2f	21	(m)W	31	4d	41	2g
2	UNDER-RANGE	12	D.P.2	22	n W	32	4c	42	1g
3	BATT LOW	13	3b	23	ZERO	33	4g	43	1d
4	1b	14	3a	24	µW	34	3e	44	1c
5	1a	15	3f	25		35	3d	45	1a
6		16	D.P.3	26		36	3c	46	-(minus)
7	1f	17	4b	27	rel	37	3g	47	OVER RANGE
8	D.P.1	18	4a	28	dB(m)	38	2e	48	
9	2b	19	4f	29	(dB)m	39	2d	49	REMOTE
10	2a	20	m(w)	30	4e	40	2c	50	



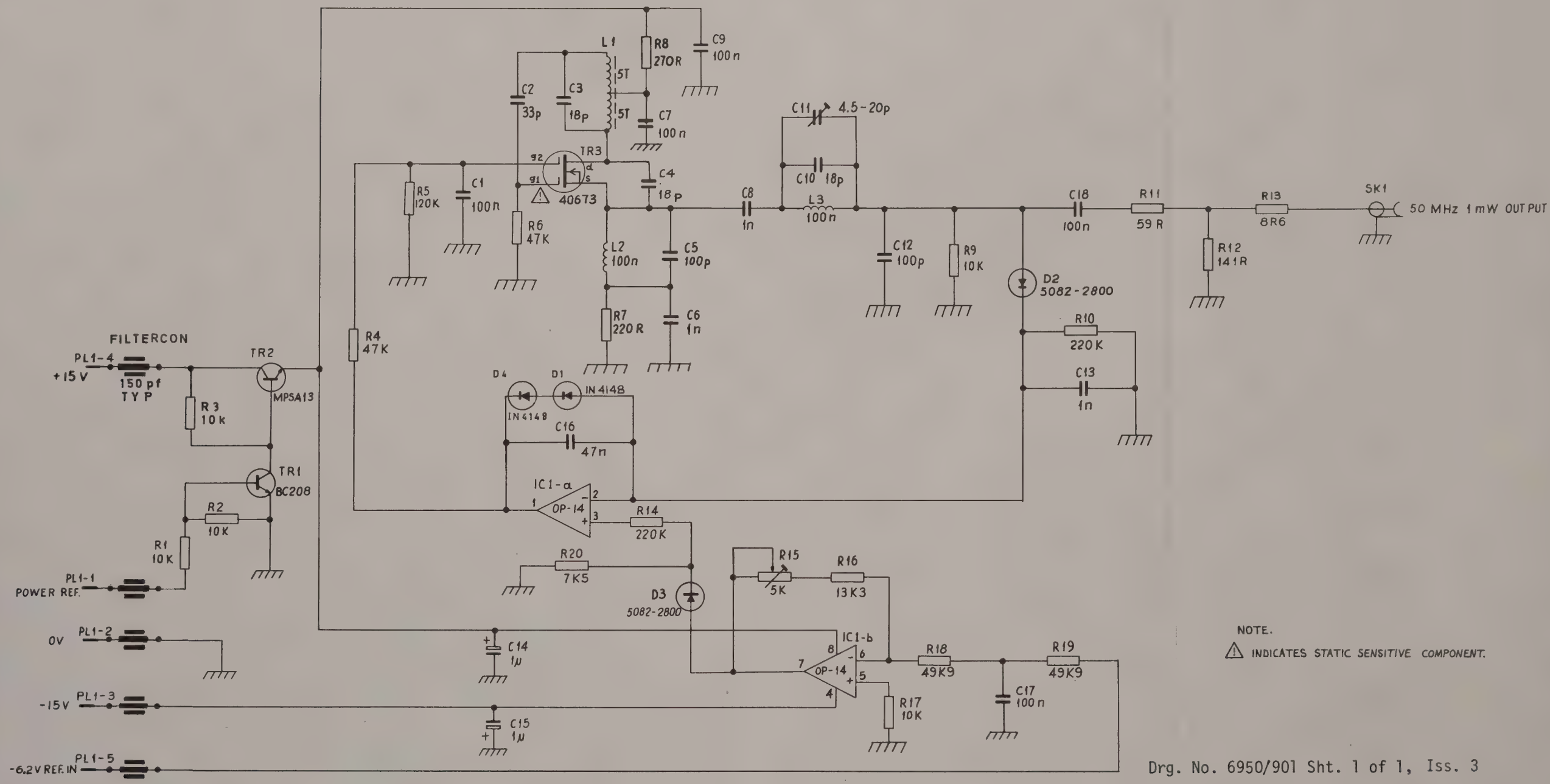
Drg. No. 6960/902 Sht. 1 of 1, Iss. 1

ABO1 : Power meter keyboard and display assembly





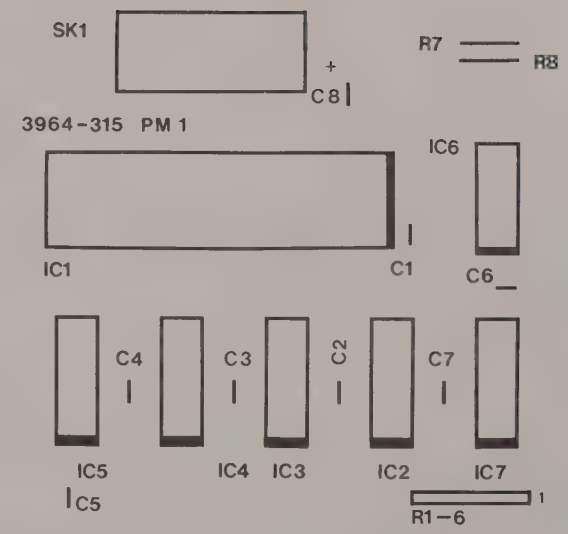
Component layout and board detail : AC04

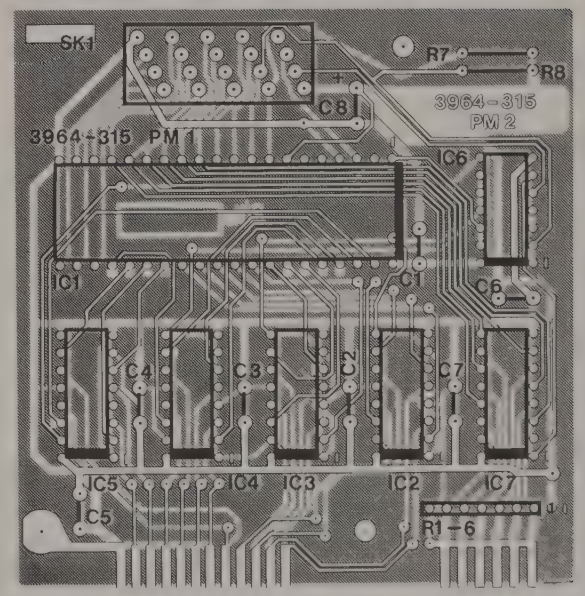


NOTE.
⚠ INDICATES STATIC SENSITIVE COMPONENT.

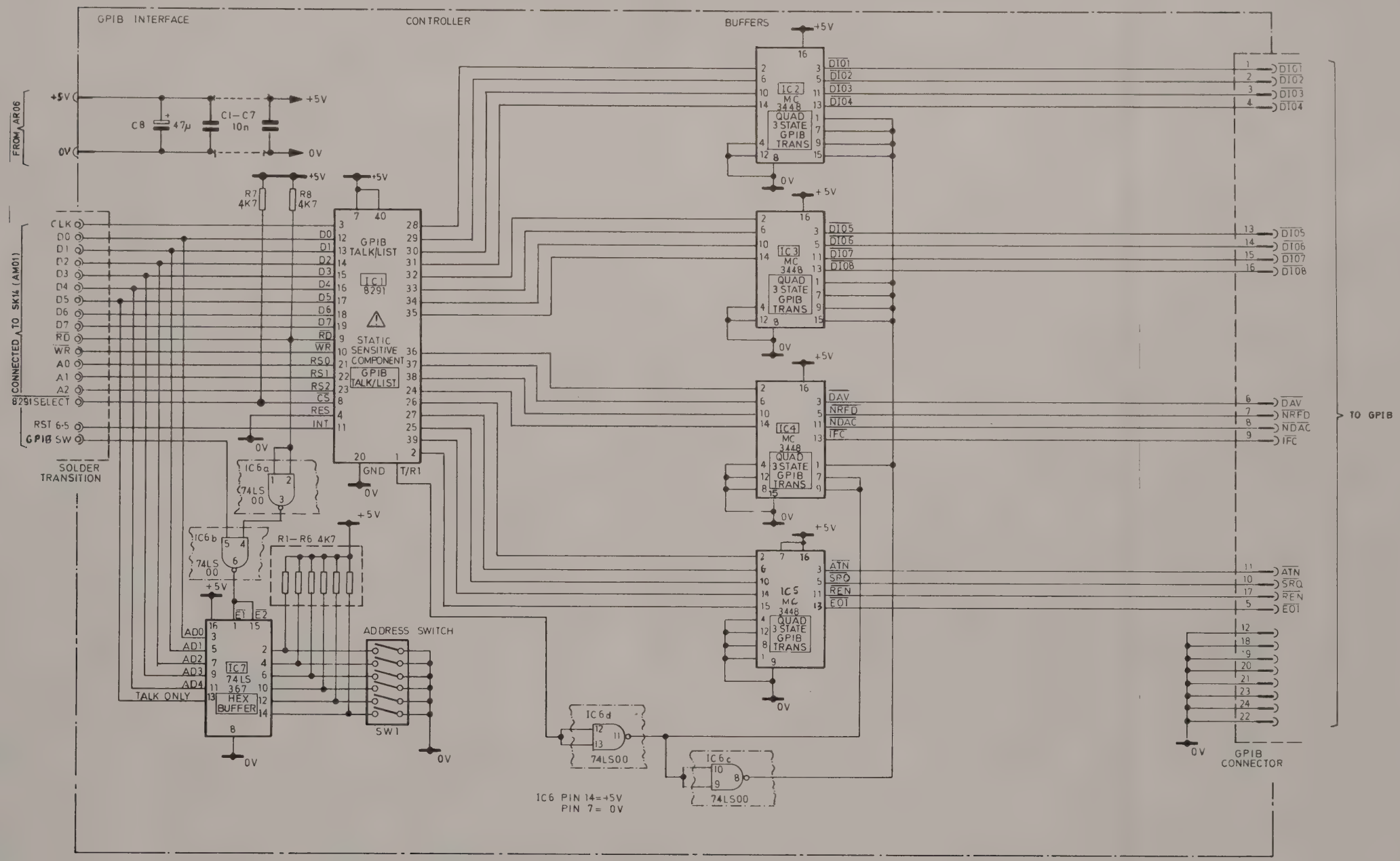
Drg. No. 6950/901 Sht. 1 of 1, Iss. 3

Power reference assembly : AC04





Component layout and board detail

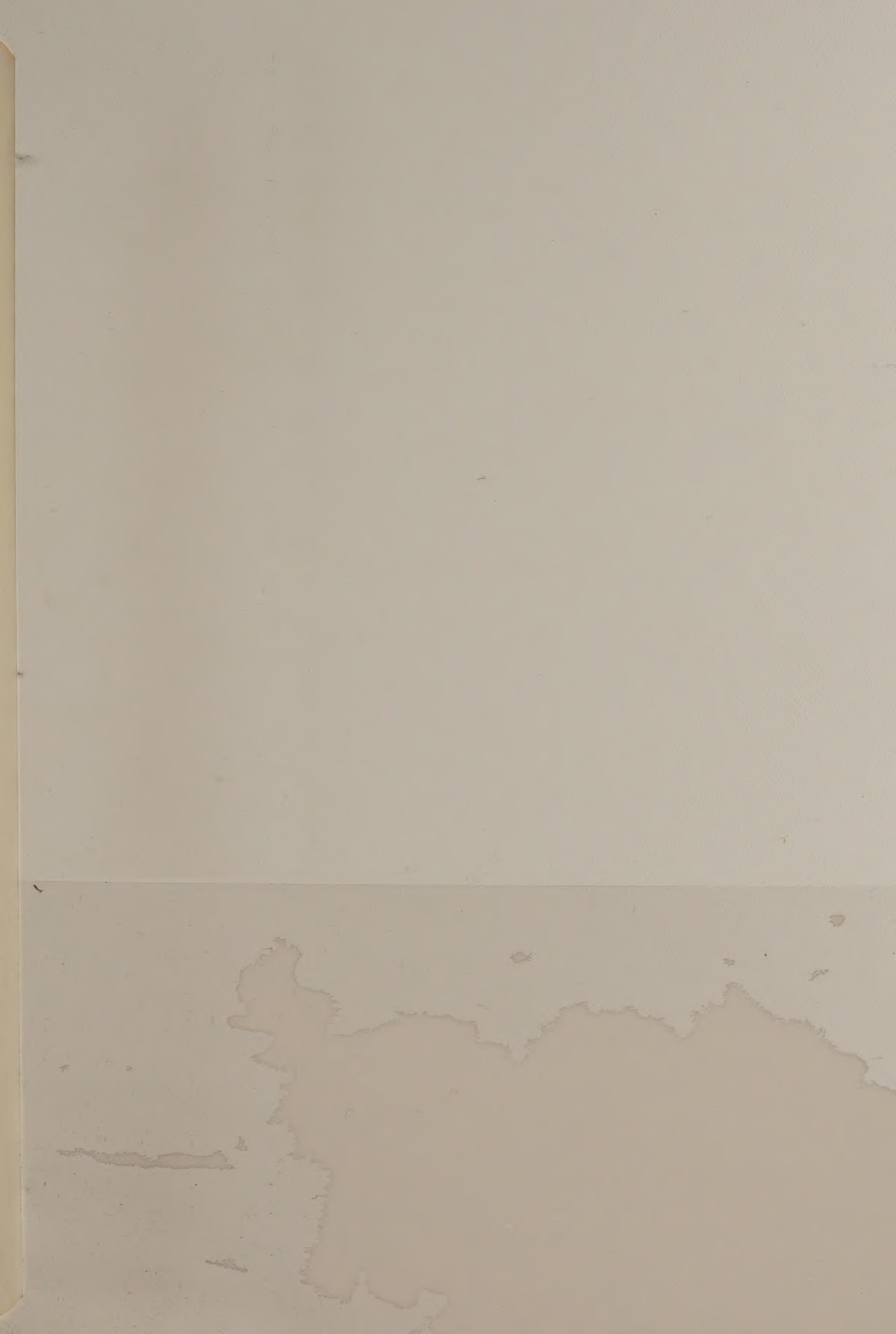


Drg. No. 3964/921, Sht. 1 of 1, Iss. 1

GPIB Interface module

MARCONI INSTRUMENTS LIMITED

SERVICE DIVISION	The Airport LUTON Bedfordshire LU2 9NS Telephone: (0582) 33866 Telex: 825248
HEAD OFFICE	Longacres ST ALBANS Hertfordshire AL4 0JN Telephone: (0727) 59292 Telex: 23350 Fax: (0727) 57481(Gp.3)
FRANCE	MARCONI INSTRUMENTS 18 Rue du Plessis-Briard, Le Canal Courcouronnes 91023 EVRY Telephone: (16) 077 9066 Telex: 690482 Fax: (16) 077 6922
GERMAN FEDERAL REPUBLIC	MARCONI MESSTECHNIK GmbH Landsberger Strasse 65 Postfach 1929 8034 GERMERING Telephone: (089) 84 9360 Telex: 5212642 Fax: (089) 84 19142(Gp.3)
SPAIN	MARCONI INSTRUMENTOS S.A. General Yague 6 bis-5 28020 MADRID Telephone: (1) 455 0391 Fax: (1) 455 1922 (Gp. 3)
USA	MARCONI INSTRUMENTS 3 Pearl Court Allendale Park ALLENDALE New Jersey 07401 Telephone: (201) 934 9050 Telex: 6853077 MIUSA Twx: (710) 991 9752 Fax: (201) 934 9229



MP MASTER
MA31160